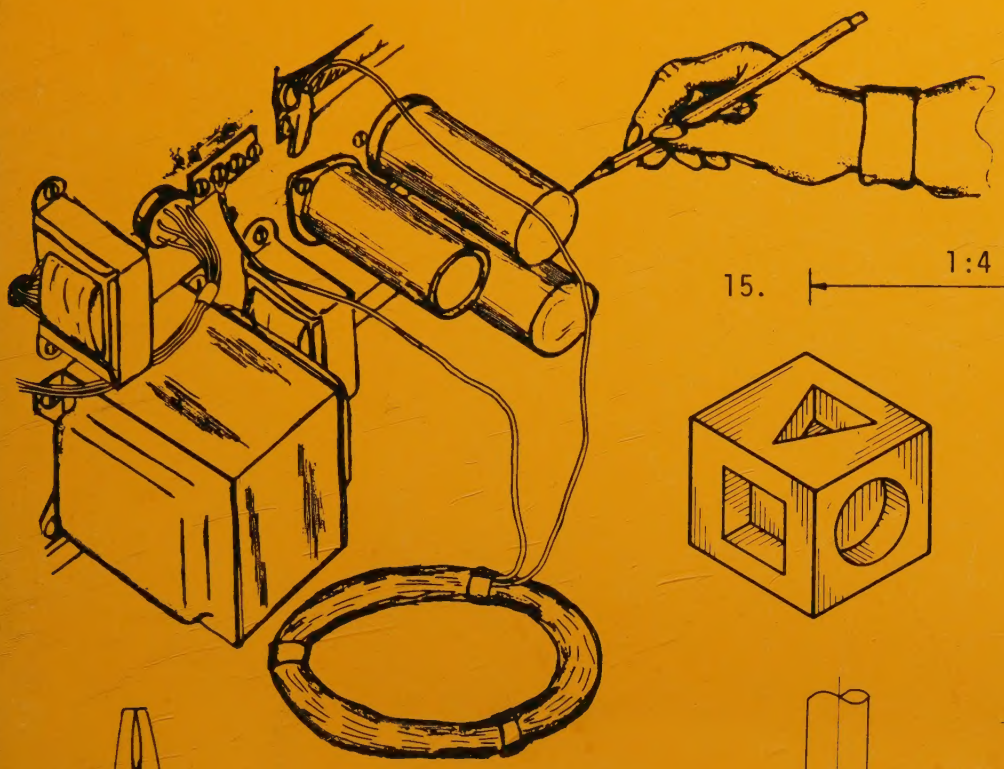
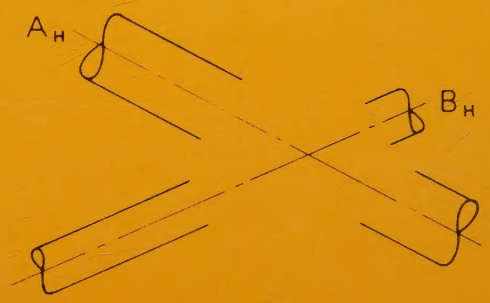
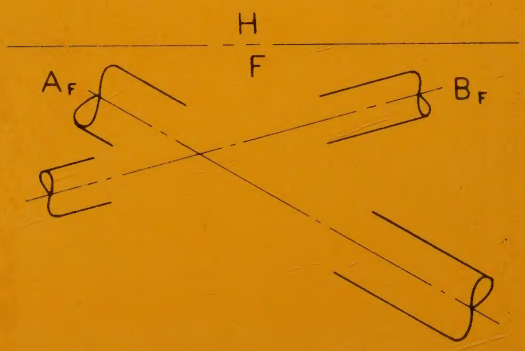
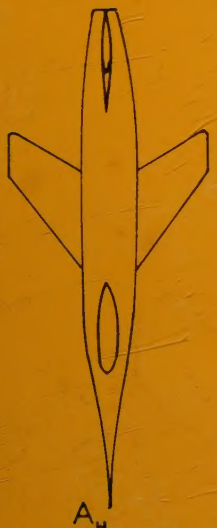
ENGINEERING GRAPHICS Problem Book

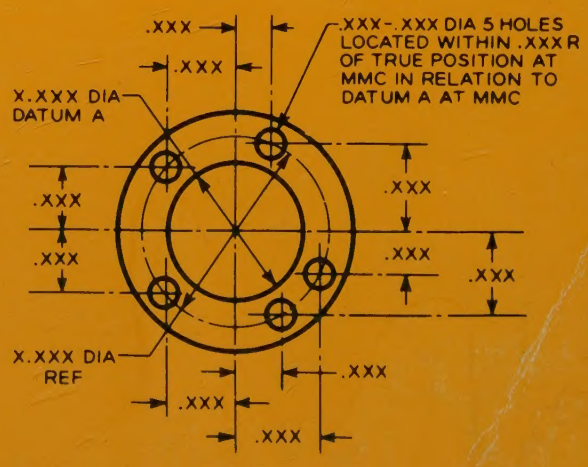
- Sanders
- Arnbal
- Crawford

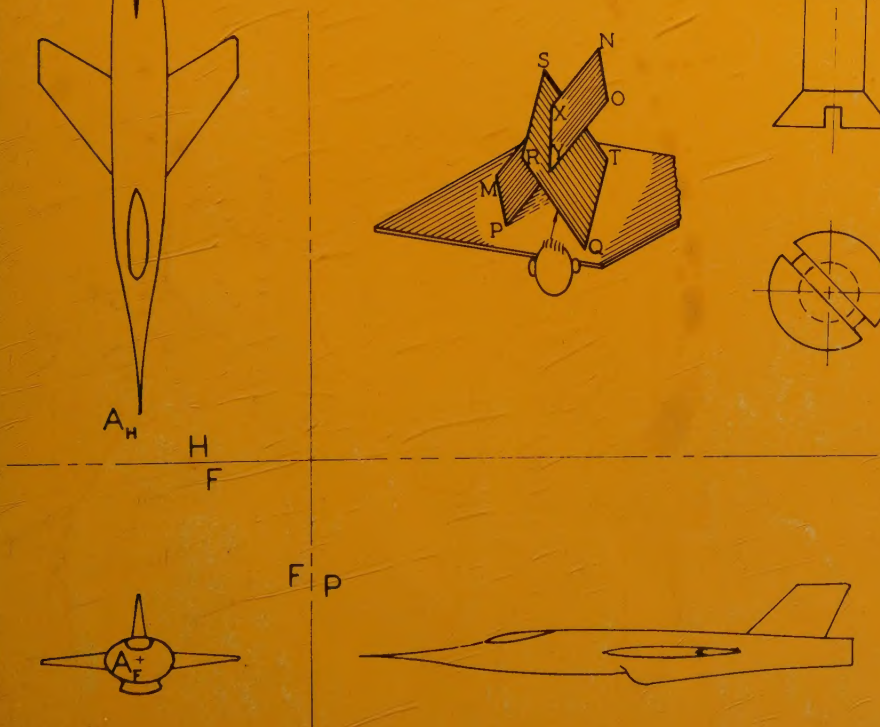












ENGINEERING GRAPHICS PROBLEM BOOK

Analysis—Synthesis—Communication

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Correlated with
Engineering Graphic—**Rising, Almfeldt and DeJong**

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PREFACE

This revised edition of *Engineering Graphics Problem Book* by Sanders, Arnbal, and Crawford has been designed to be used in conjunction with a basic graphics course for freshman engineering students.

Sufficient, appropriate material in both range and degree of difficulty has been included to fully meet the requirements of either a 3-5 quarter hour credit, or a 3-5 semester hour credit course, covering fundamentals in what is commonly referred to as basic graphics or drawing and descriptive geometry.

In perusing the material in this book it is suggested that the following points should be thoughtfully noted.

- The table of contents lists easy to find, easy to assign major subject categories stated in commonly used terminology.
- Each major unit is introduced with a statement of objectives for the problems involved and a brief explanation of the relevance of the problems in both the educational and industrial environments.
- Solution principles are stressed prior to, and in conjunction with, the application problems.
- Several unique self-study, visualization exercises to strengthen important solution principles have been retained and refined.
- Special effort has been made to arrange problems for a given unit in a carefully graduated sequence starting with the simplest and progressing to the more challenging application problems.
- In each new unit introduced, deliberate review of preceding principles is incorporated in the solution requirements.

This problem book and the text *Engineering Graphics* by Rising, Almfeldt and DeJong is used in the first of a sequence of engineering courses including Engineering Graphics, Engineering Computations and Foundation for Engineering Design required in all freshman engineering curricula at Iowa State University.

Although subject areas and certain terms in this book have been "keyed" to the text *Engineering Graphics*—Rising, Almfeldt and DeJong the selection, grouping of material and the terminology used will be found compatible with any of the excellent graphics texts currently in vogue.

The authors hope that students using the problem sheets herein will appreciate having the repetitive, tedious and time consuming layout work of the respective problems accomplished for them in order that they may achieve a more interesting and comprehensive understanding of important principles and techniques than would otherwise be possible.

The authors would be pleased to receive both constructive criticism and enthusiastic endorsements from students and others using this revised edition.

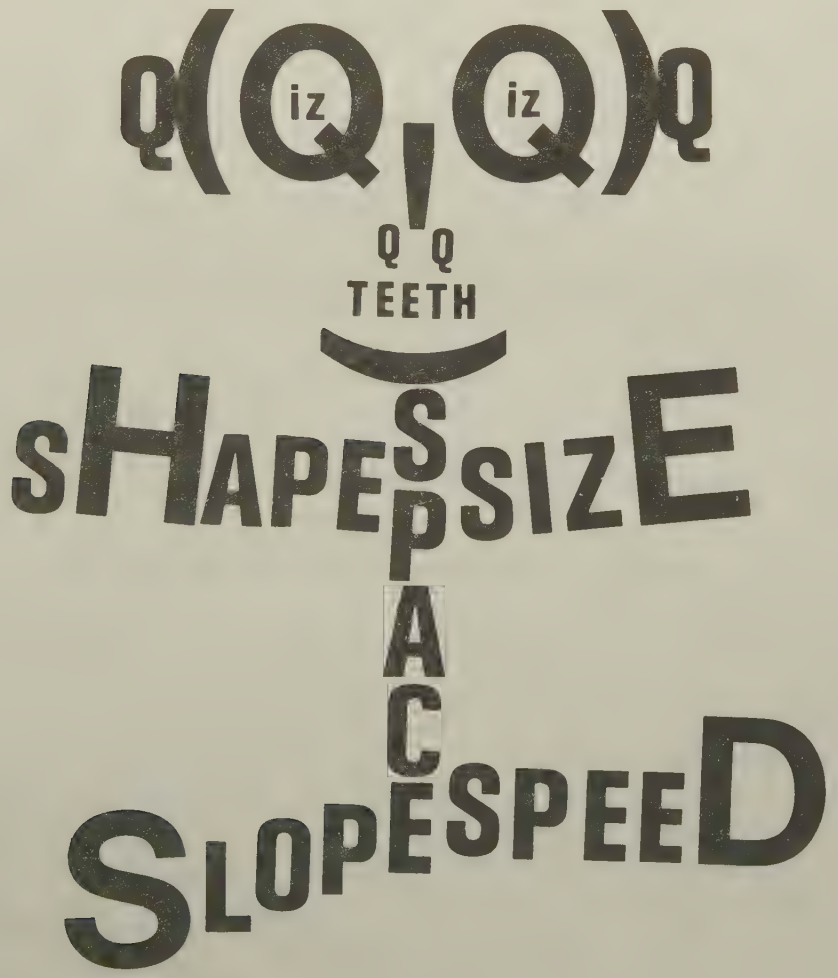
ENGINEERING LETTERING

USE

- Lettering is used to a great extent for titles, legends, notes, labeling and the variety of specifications found throughout the areas of engineering graphics and design. It is also used in conjunction with computations and notes for engineering reports and records.

OBJECTIVES

- Be able to illustrate without assistance or the use of reference material: the correct use of guidelines for controlling uniformity in the height of letters; the basic shape of each of the gothic letters (capitals and lower case) and numerals; the important rules of composition (spacing of letters within words and words within sentences).
- Develop a degree of skill in execution of lettering that approaches the quality illustrated in your text. Develop as rapid a rate of speed in lettering as you can, consistent with maintaining good quality.



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GRADE:
DR. BY:
INSTRUCTOR:
DATE:
TABLE:
COURSE:
SECTION:

LETTERING

Importance of Lettering to an Engineer

A. From the beginning of your engineering career you should develop the ability to execute uniform, legible lettering at a rapid rate of speed. It may be used in many areas of your work. While in college you will find that a good ability to letter will be an aid in outlining and note taking during course work in almost all disciplines. It will facilitate technical work in subjects such as engineering design, mechanics, physics and mathematics. As a practicing engineer you will use lettering for recording design ideas, project reports, mathematical computations and many kinds of data.

1. While rereading the above statements, underline the words that describe in general terms the kind of lettering you, in your chosen career, should be capable of executing.
2. Underline the words that describe where you may utilize lettering in college work.
3. Same, for "as a practicing engineer."

B. Essential Characteristics of Lettering

In referring to letters and numerals:

Size is generally a reference to height;
Shape refers to general characteristics such as straight or curved segments, proportions, etc.;
Slope indicates position (vertical or inclined);
Space refers to the void area existing between consecutive letters in a word or between words in a sentence;
Speed refers to how rapidly one can accomplish freehand lettering.

1. Underline the "five S's" of lettering above (those single words that best describe the essential characteristics of lettering).

C. ASA Standard Letters and Numerals

1. Tape a sheet of vellum (tracing paper) over the sheet of ASA Standard Letters and Numerals and rule light and accurate guide lines having the same heights as the given letter and numerals. Study the proportions and characteristics of each letter (or number) and with an H pencil carefully, but smoothly and quickly, trace the vertical letters/characters on the vellum.
2. Carefully study the similarities and differences between the capital and lower case for each letter.
3. Same as 1 and 2 above except trace the inclined characters.

A B C D E F G H I J K L M N O P
Q R S T U V W X Y Z & 8
a b c d e f g h i j k l m n o p q r s t u v w
x y z 1 2 3 4 5 6 7 8 9 0
A B C D E F G H I J K L M N O P
Q R S T U V W X Y Z & 8
a b c d e f g h i j k l m n o p q r s t u v w
x y z 1 2 3 4 5 6 7 8 9 0

IOWA STATE UNIVERSITY STANDARD LETTERS & NUMERALS	COURSE: 161 DATE: 9-15- DR. BY: JOHN J. JOHNSON SECTION: 5 TABLE: 142 INSTRUCTOR: M.W. ALMFELDT	DR. NO. 1A GRADE:

LETTERING EXERCISES

DR. NO.:

GRADE:

A. The basic shape of several of the vertical capital and lower case letters is that of a circle, or some part thereof. On line 1, in alphabetical sequence, complete each capital letter whose basic shape corresponds at least partially to the circles already formed. Repeat the exercise on line 2 by *lightly* forming a row of similar circles of uniform height (freehand) and again forming the letters. Repeat this process on line 3 and line 4 for *lower case* letters.

Line 1

Line 2

Line 3

Line 4

B. Using the squares on the guide lines below letter the alphabet first in caps and then in lower case.

C. Letter the following numerals and fractions using the guide lines below: 10 3/4, 2 7/8, 5 9/16, 10.39.

Note: Observe the example and use similar spacing—note especially the space between fraction bar and numerator and denominator.

$7\frac{3}{16}$

D. On the guide lines below letter in vertical caps the following sentences paying particular attention to spacing and speed.

"Neatness, uniformity and organization are traits that can be developed through an engineering education."

DR. BY:

INSTRUCTOR:

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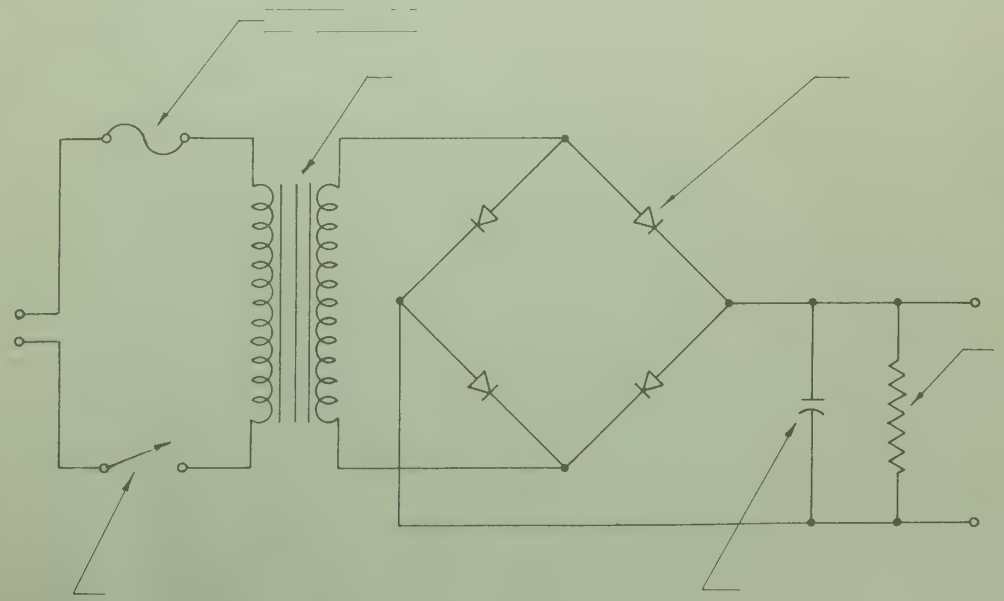
DR. NO.:
GRADE:

LETTERING EXERCISES

A. Freehand (very lightly) sketch guide lines for about 0.1" letter height and carefully letter in the missing words (the S's of lettering) in the following statements.
Good lettering results from: learning the characteristics in form and proportion (the _____ of each letter or numeral); consistently using guide lines to insure uniformity in the _____ of each character; attention to the uniform position of the characters in relation to a theoretical vertical axis (the _____ of the letter) (in this respect, lettering is classified as either _____ or _____); always maintaining a proper void area (_____) between letters within a word or between words within a sentence; persistent attention to the foregoing features together with diligent effort and practice and you will be able to letter at a satisfactory rate of _____.
CAUTION: If future course work requires long answers (words) and you are pressed for time, use longhand or typing. . . . Don't practice poor lettering!! Remember it's perfect practice that makes perfect, not just practice!

B. Freehand (very lightly) sketch two sets of 0.15" guide lines and letter the following in vertical caps. Your name, social security number, home town.

C. On the given electrical layout identify each symbol by carefully lettering its name by the appropriate leader. Sketch very light freehand guide lines similar to those that have been drawn for the fuse. Refer to appendix of your text for names of the symbols.



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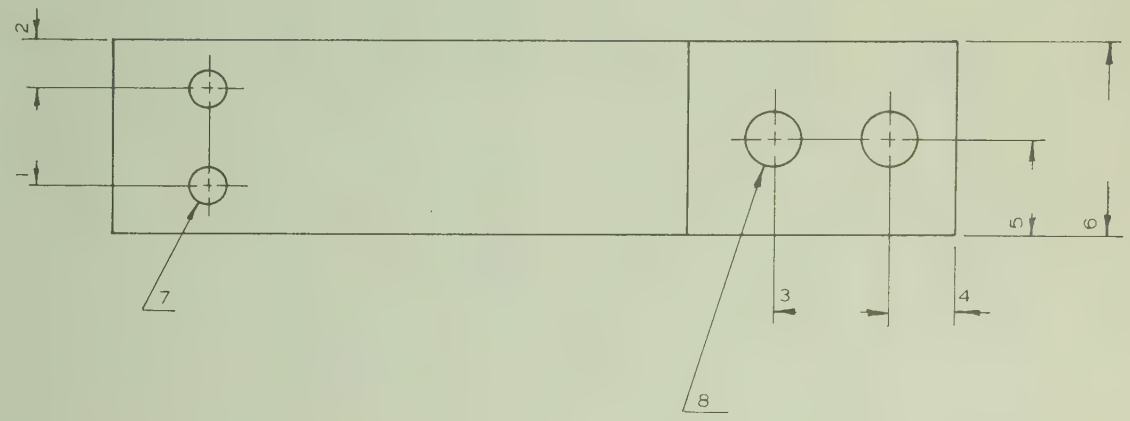
LETTERING EXERCISE

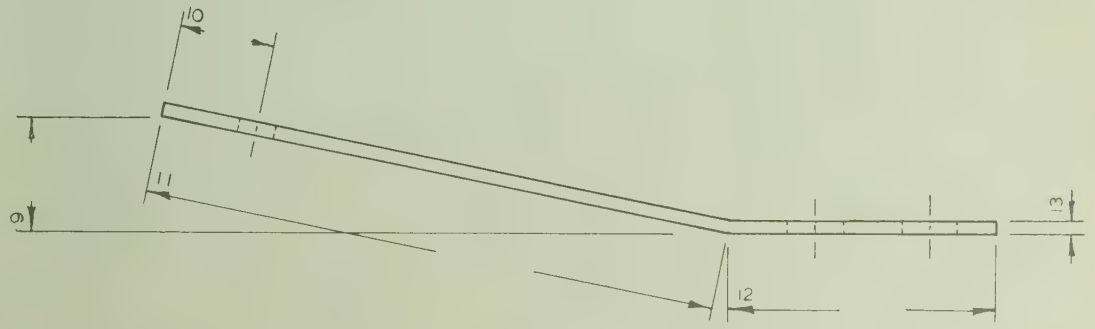
A. Letter the following dimensions and notes where indicated. Use guide lines for 0.1" letter height and letter in vertical caps.

1. 0.50
2. 0.25
3. 0.60
4. 0.35
5. 0.50
6. 1.00
7. #10(.193) Drill
   2 Holes
8. $\frac{9}{32}$ Drill
   2 Holes
9. 0.60
10. 0.50
11. 3.00
12. 1.40
13. .062
14. Note:
    Hardness:
    Rockwell C40-C45
15. Note:
    CAD Plate .0003" thick
    Heat treat to remove hydrogen embrittlement
16. Title Plate:
    Name: Friction Spring
    Material: 1065-1085 carbon spring steel
    .062" X 1" X 4.5" long
    No. Reqd: 2
    Scale: 1" = 1"

B. Do only the odd numbered listed under A above.

16. TITLE PLATE:





15. NOTE:

14. NOTE:

	COURSE:	DATE:	DR. BY:	DR. NO.
	SECTION:	TABLE:	INSTRUCTOR:	GRADE:

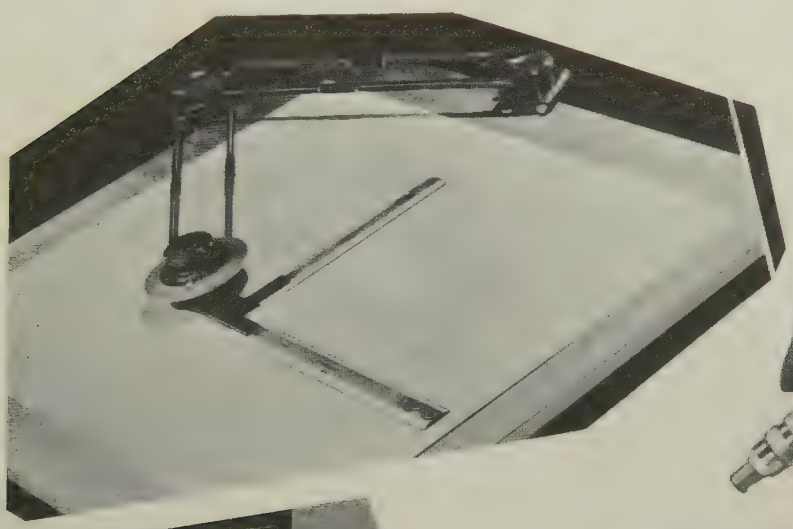
DRAWING EQUIPMENT

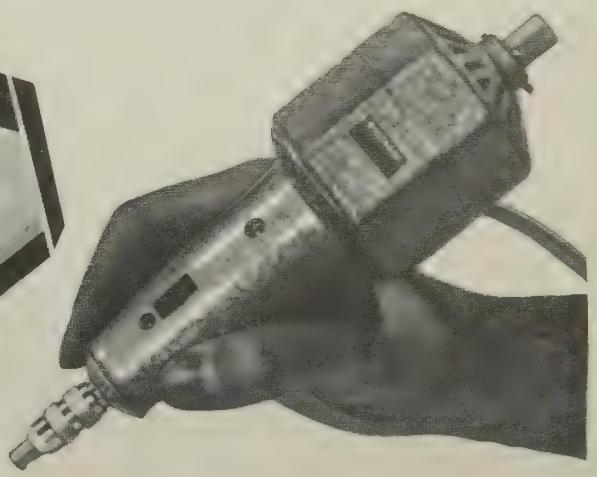
USE

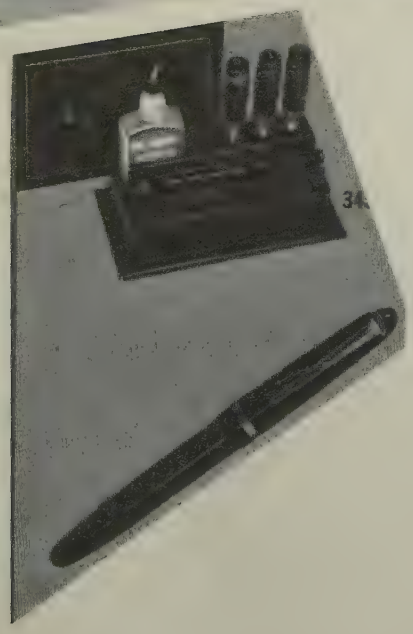
- In all situations where a high degree of precision is needed in graphical delineation.

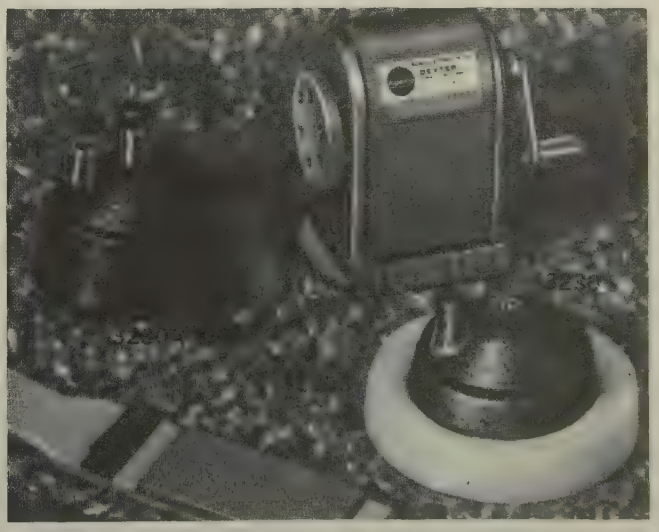
OBJECTIVES

- Learn nomenclature—Be able to name the various pieces of equipment.
- Practice organizing equipment—Demonstrate daily a consistent, orderly plan for arranging equipment at your desk.
- Learn efficient manipulation of your instruments. Be able to demonstrate accepted standard techniques in handling triangles, tee square, compass, scales and other items.





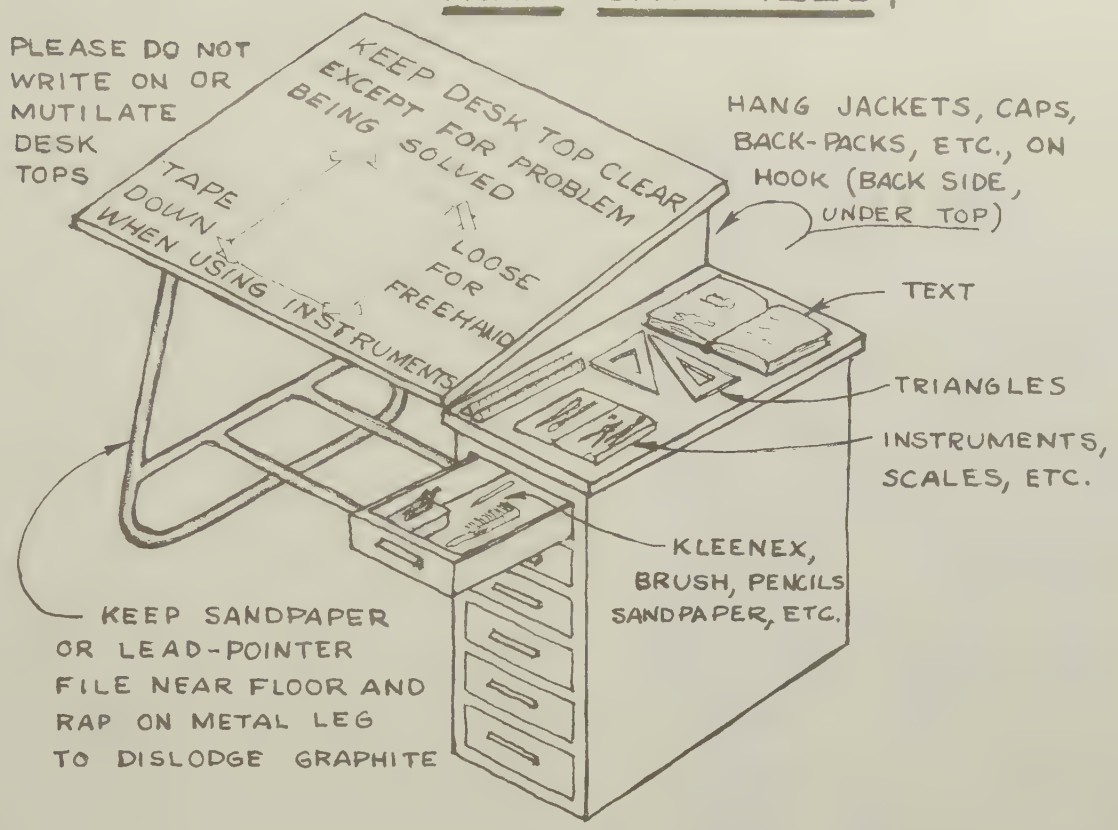




DR. NO.

GRADE:

KEEP ORGANIZED!


PLEASE DO NOT WRITE ON OR MUTILATE DESK TOPS
KEEP DESK TOP CLEAR EXCEPT FOR PROBLEM BEING SOLVED
TAPE DOWN WHEN USING INSTRUMENTS
LOOSE FOR FREEHAND
HANG JACKETS, CAPS, BACK-PACKS, ETC., ON HOOK (BACK SIDE, UNDER TOP)
TEXT
TRIANGLES
INSTRUMENTS, SCALES, ETC.
KLEENEX, BRUSH, PENCILS SANDPAPER, ETC.
KEEP SANDPAPER OR LEAD-POINTER FILE NEAR FLOOR AND RAP ON METAL LEG TO DISLODGE GRAPHITE

DR. BY:

INSTRUCTOR:

DATE:

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SECTION:

"A place for everything and everything in its place!"

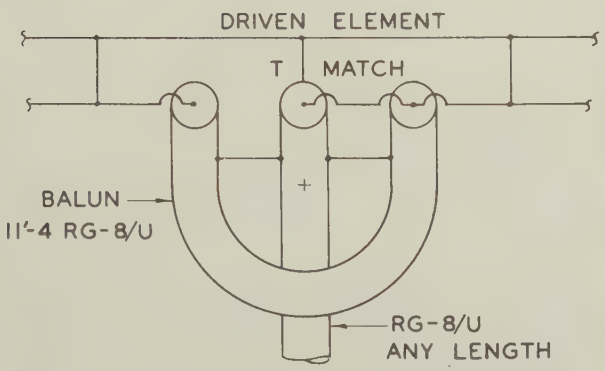
The above illustration is only a suggestion for organizing your equipment and supplies relative to your drafting table. However, it is extremely important to establish a systematic organization of your tools and supplies so that they are always located in approximately the same relative place, convenient to you and yet not in the way while drafting or sketching.

Above all, keep the upper main working surface clear of wearing apparel, books and bulky objects. Keep those items used most frequently—most accessible. Keep the table surface (per se) clean and free from writing, computations or childish carving, etc.

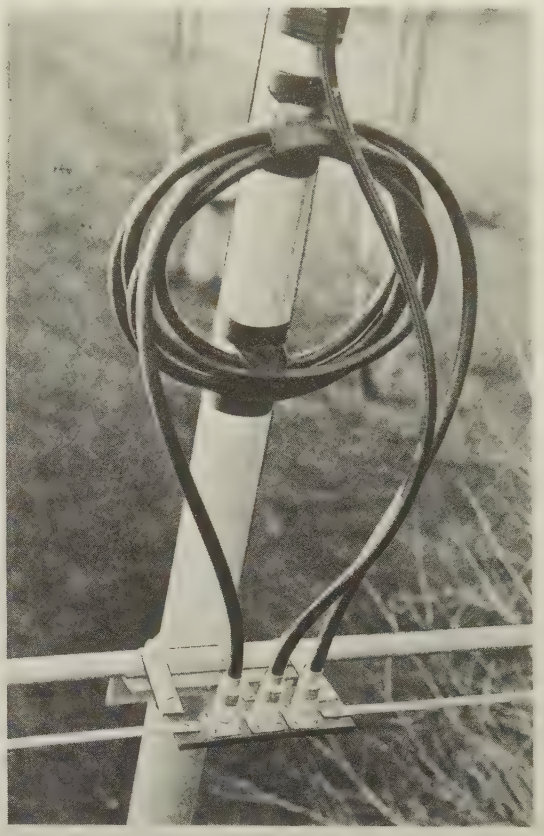
If necessary ask your instructor for individual assistance while learning to use your instruments. In many cases you can cut drafting time in half just by proper use of the triangles. Use guidelines for lettering and always strive for good quality lettering and line work.

INSTRUMENT EXERCISES

A. Using the dividers to transfer measurements make a double size drawing on a blank sheet of the given figure of a coaxial-line termination board. Leave *light* construction lines to show exact points of tangency, centers, etc.

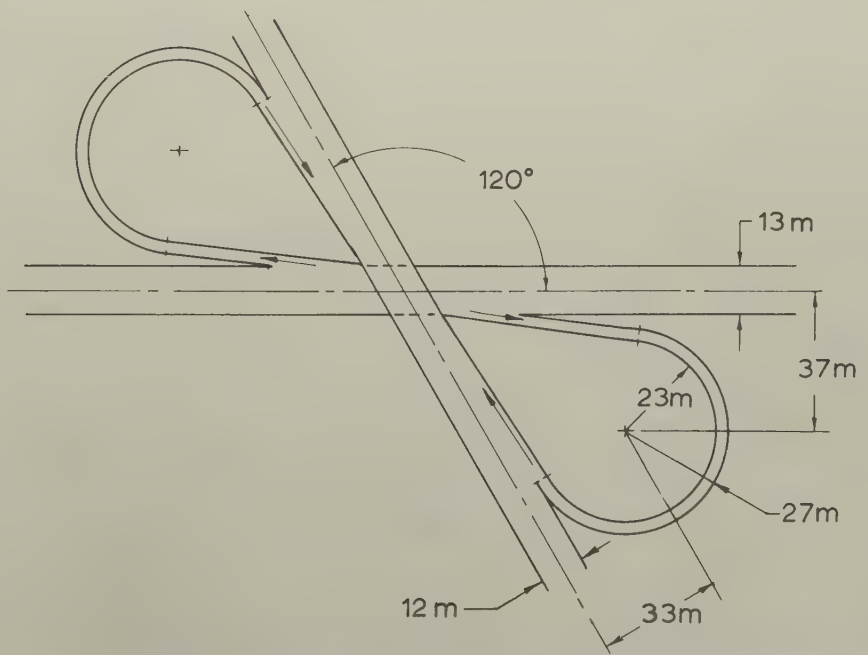


Details of a coaxial-line termination board and T-match support for a 10-meter beam. The balun of a half-wavelength of coaxial line is coiled and then fastened to the boom with tape (right).



Courtesy of The American Radio Relay League, Inc.

B. A portion of a freeway interchange is shown below. Transfer this view to a blank sheet, scale 1:1000.



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A. Draw appropriate guidelines and record each missing scale, ratio, dimension (value and unit), and physical measurement (arrowhead).

B. Complete only the odd numbered exercises.

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DR. NO.:_

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INSTRUCTOR:_

DATE:_

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COURSE:_

SECTION:_

	Scale	Ratio	Dimension	Measurement
1.	1" = 1" (full)			
2.	1" = 2" (half)			
3.	1" = 0.5" (dble)			
4.	1" = 1'		5.4'	
5.	1" = 30'			
6.		1:6	34.5"	
7.		1:60		
8.	1" = 4'		19.5'	
9.	1" = 6 mi			
10.	1" = 50 lb			
11.	1" = 2000 bl		10050 bl	
12.			yd (120 < val < 170)	
13.		1:480	202'	
14.	1" = $60			
15.	1" = 5"		28.8"	
16.		1:0.2		
17.		1:1 267 200	110 mi	
18.			6'	
19.			(14' < val < 20')	
20.		1:0.04	0.225"	

A. Draw appropriate guidelines and record each missing ratio, dimension and physical measurement (arrowhead).

B. Supplement/review: Change ratios and/or dimension values and rework.

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DR. NO.:_

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INSTRUCTOR:_

DATE:_

TABLE:_

COURSE:_

SECTION:_

	Ratio	Dimension	Measurement
1.		15 m	
2.		15 cm	
3.		15 mm	
4.		15 km	
5.	1:0.01	mm	
6.		1.33 cm	
7.	1:50	7.2 m	
8.		0.72 m	
9.	1:0.02	mm	
10.	1:0.2	2.07	
11.	1:20 000	km	
12.		280 mm	
13.	1:33 1/3	m	
14.	1:0.8	10.05 cm	
15.	1:4	mm	
16.	1:0.08	10.5	
17.		590 km	
18.	(double size)	68.4 mm	
19.	(full size)	140.5 mm	
20.	(half size)	cm	

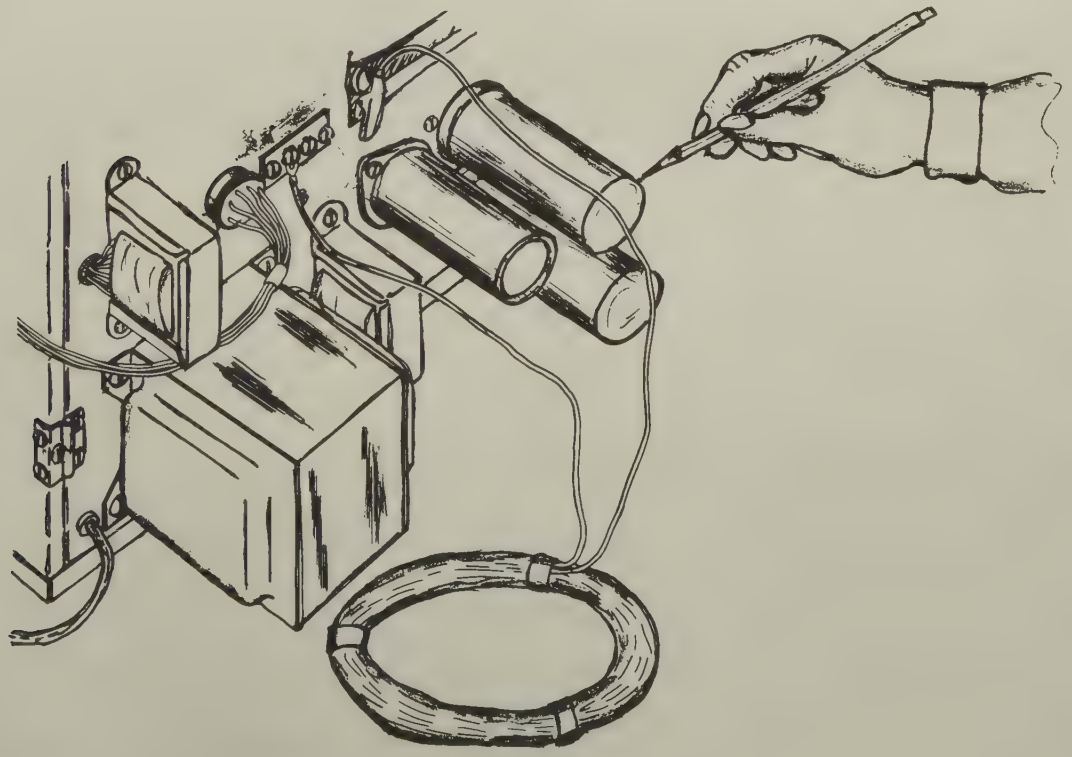
FREEHAND DRAWINGS

USE

- Useful to engineering students while in college and later as practicing engineers for assisting in the development of ideas, the retention of ideas, for creative expression and for communicating ideas to other people. As true today as ever—"A picture is worth ten thousand words."

OBJECTIVES

- Be able to distinguish between the various types of sketches and to select the appropriate type to use for a given application.
- Use effective sketching procedures and techniques—without the use of reference material or other assistance, be able to list, or demonstrate by actual application, the prescribed sequence of steps in the planning and execution of a sketch.
- Develop the desire to sketch—ask to do laboratory work freehand, do optional work freehand, overcome any tendency to complain when asked to work freehand.
- Develop speed in sketching—work calmly under time limits, and meet time deadlines with acceptable work.
- Develop care in sketching—rapidly execute sketches showing important details in correct proportion, with good line quality and a *crisp* overall appearance. (See sample below.)



SKETCHING

13

DR. NO.

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Note: Study the unit on sketching in your text!

A. Neatly letter the missing word(s) in the blank spaces!

1. A sketch is a _____ delineation.
2. Sketches using one two-dimensional orthographic view are classified as _____ _____ sketches; those using two or more related two-dimensional views are _____ sketches; and those using a three-dimensional single image is a _____ sketch.

B. The advantages of sketches over instrument drawings include: Convenience (frequently instruments are not readily available); Sketching is less restrictive than instrument work (allows ones mind to focus on the idea or subject rather than the mechanics of recording an image); Sketching is, or should be, accomplished much faster than instrument drawing.

1. As an engineer you will make sketches (less) (more) frequently than instrument drawings. You will use sketches while originating ideas for preliminary _____ or _____ _____ (as a quick translation of ideas into _____ form); to _____ ideas (to "jog" memory); to effectively _____ with other people—to explain to them the _____ or _____ of a system or device. Develop this worthwhile skill as rapidly and as well as you can.
2. While re-reading preceding statements underline the key words that best describe the advantages of sketching over instrument drawings and those that describe the *when* and *why* of sketching.

C. Plan your sketch, i.e., decide on its purpose, who will use it and why, the desired view or views of the object, plus, the type of sketch, number and position of views, the position of axes and the amount and type of accompanying information such as dimensions and other specifications.

1. Cover the above paragraph and *lightly* (in longhand on a sheet of scratch paper) list in numbered sequence the important decisions you should make prior to actually making a sketch.
2. Check and correct this list so that it corresponds to the information above and keep for reference.

D. Execution

1. All _____ work (which includes the first delineation of almost the entire object) should be sketched lightly so that _____ can be erased, changes in proportion, spacing, etc., made before the lines are _____.
2. Sketch in an overall " _____ box" or important _____ lines and boundary lines that define the overall _____ or limits of the object. Box in _____ views if a multiview sketch is planned.

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ANSWERS–13

A. 1. freehand

2. single view
multiview
pictorial

B. 1. more
design or layout
visible
retain
communicate
form, function

C. See given problem.

D. 1. construction
errors
darkened

2. "skeleton box"
center
size
all

SKETCHING

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A. Study text illustrations on sketching procedures.

1. Keeping your eyes focused on point B (the objective) sketch a straight line from A to B, then from C to D, C to A and D to B.

A +

+ B

C +

+ D

2. Let the above rectangle ABCD represent a plot of land from which a developer wishes to sell lots, each to be 1/16 of the total area and of the same proportion as the original plot. Locate points half way on each line. Using the techniques described in (1) divide the plot in 4 equal parts. Repeat this process again with each quarter of the original plot. Quickly, carefully darken the lines.

3. Repeat (1) and (2) on another sheet of paper dividing the original plot into 25 equal lots of the same proportion as the original plot.

B. Carefully letter answers to the following or underline choices as appropriate.

1. The small rectangles (in Problem A2) are in the same _____ as the original large one.

2. To draw a straight line one should focus the eyes on (the pencil point) (the objective).

C. 1. Using a sheet of plain paper and techniques described in your text, lightly, quickly sketch a 3 inch diameter circle (estimate). Check size with scale—if off more than .25 inch erase completely and estimate size again. Repeat until within .25 limits. Using correct techniques, sketch a row of 4 more circles the diameter of each being one-half that of the preceding one and tangent to the preceding one and to a straight line (darken the circles and show construction lightly).

2. Repeat exercise (1) starting with a 2.5 inch diameter circle and sketch 4 more circles the diameter of each three-fourths that of the preceding one.

3. Using proper techniques sketch a 1.5 inch diameter (estimate) circle at any point A. On the horizontal center line at a distance from point A equal to twice the diameter of the first circle, construct a second center line perpendicular to the first. On this center line construct 2 circles each 1/2 the diameter of the circle at A and tangent to each other. Sketch straight lines tangent to and bounding all three circles. Darken the boundary only, i.e., the arcs and the straight lines between tangent points.

ANSWERS—14

A. 1, 2, 3, Check problem statement, if in doubt, ask your instructor.

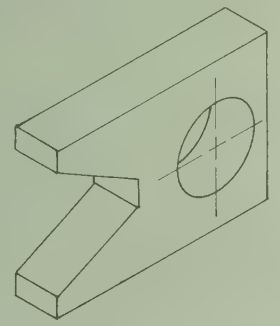
B. 1. proportion

2. (the objective)

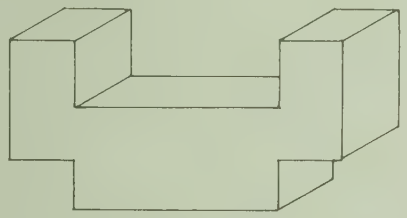
3, 4, 5, Check problem statements, measure circles with scale, or ask instructor to check your work.

Make a single view sketch of each of the following objects. Select the view that best shows the contours for each object.

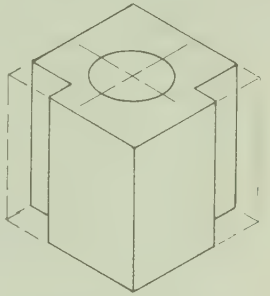
A.



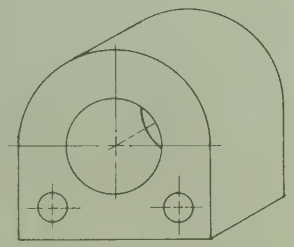
B.



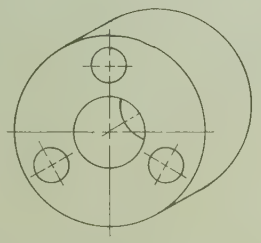
C.



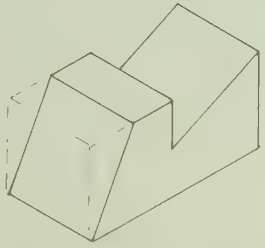
D.



E.



F.



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A. Make freehand single view sketches as assigned.

B. Make freehand pictorial sketches as assigned.

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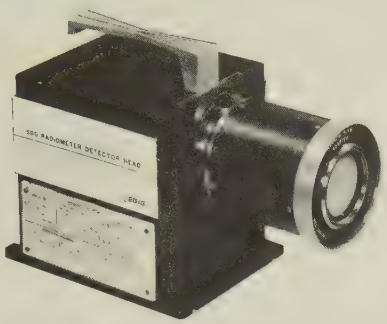
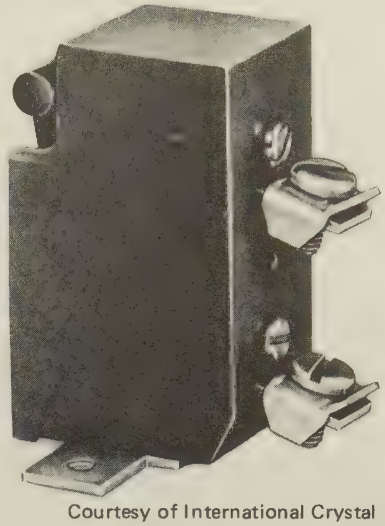


Courtesy of Electonic Products Division E G & G Inc.

1. Radiometer detector head

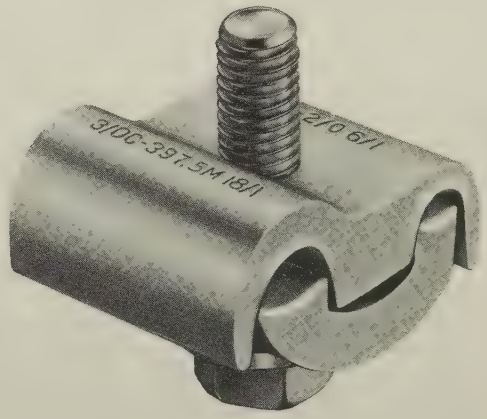


Courtesy of International Crystal Mfg. Company

4. Switch

Courtesy of Electronic Products Division

2. Variable resistor



Courtesy of Aluminum Company of America

5. Conductor clamp

DR. BY:

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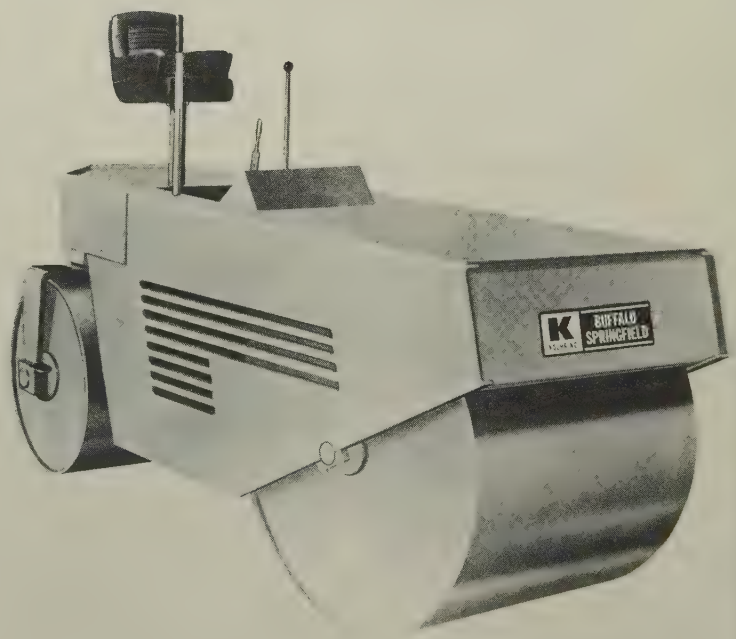
Courtesy of Bijur Lubricating Corp.

3. Pilot locator



Courtesy of Koehring Company

6. Roller

SKETCHES

A. From the following titles select subjects for sketches. Proportion the sketch to fit the working area on the sheet.

1. Baseball bat
2. Screwdriver
3. Electric light bulb
4. Rocket
5. Jet airliner
6. Automobile instrument panel
7. Wrist watch
8. Paper clip
9. Water tower
10. Mechanic's tool
11. Carpenter's tool
12. Tennis racquet
13. Traffic light
14. Flashlight
15. Coffee pot
16. Wall clock
17. Desk calendar
18. Bicycle
19. Fluorescent light
20. Automobile
21. Study desk
22. Scotch tape dispenser
23. Floor plan of home
24. Desk lamp
25. Guitar
26. Semi-trailer truck (18 wheeler)

B. Show a single-view of a radio set with speaker outline, at least two dials, and position for earphone jack. Design the template that would be used to mark a sheet of plastic to cut the outlines and necessary dial and fastener holes for the front panel.

C. Starting with very light construction lines and using symmetrical axes, make a pictorial sketch conforming to the following sequence of specifications:

1. Sketch a rectangular prism 8 units long (receding to the left), 4 units high and 6 units deep.
2. Locate a line around the prism at a height of 2 units.
3. Locate a line around the prism 4 units to left of the front corner (your construction will now look like 4 blocks each 4 × 2 × 6).
4. Remove the entire 4 × 2 × 6 block from the upper front corner.
5. On the remaining upper block, locate a line joining the midpoints of the 4 unit distance.
6. Now cut two triangular prisms from this block by drawing lines from each end of the line located in step 5 down to the lower corners of the upper block.
7. Remove a 2 × 2 × 4 portion from the front rectangular block to leave a 4 × 2 × 4 remainder.
8. Add door, windows, steps, sidewalk, etc., to transform your mutilated block into a house with an attached garage.

D. 1. Make a wiring diagram for a lighting circuit that can be turned off or on at either end of a long hallway.

2. Sketch a wiring diagram for a doorbell using house current and a transformer.

E. Make a large-scale pictorial sketch to show the dove-tail construction of the corner of a wooden desk drawer.

F. Make a single-view sketch of the spring-board found at the swimming pool in the gymnasium.

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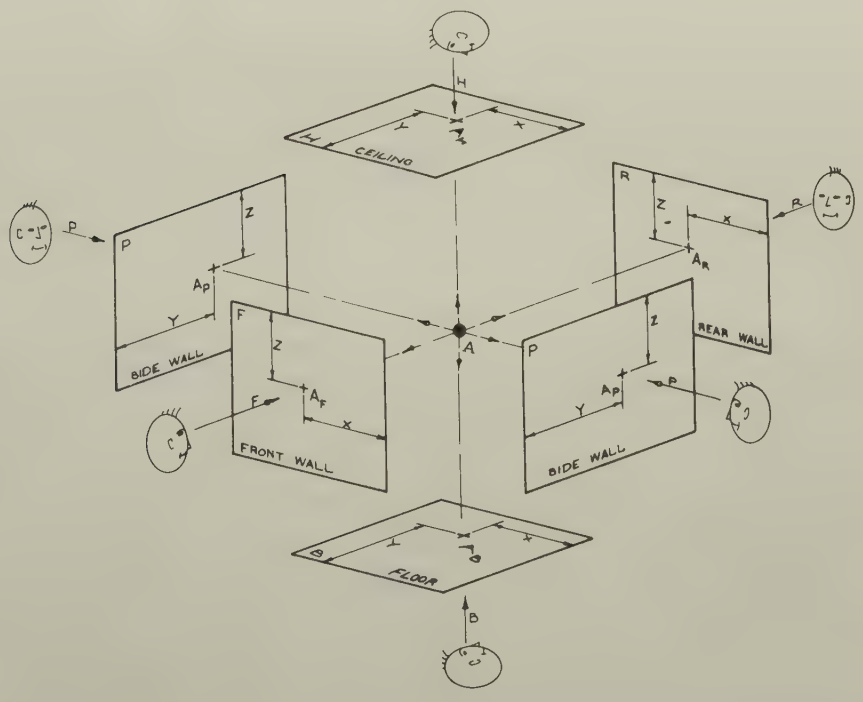
ORTHOGRAPHIC PROJECTION—POINTS

USE

- The system of orthographic projection is used around the world in conjunction with the "working drawings" used to furnish detailed and accurate information about form, manufacture, assembly or function of industrial products. Other engineering delineation such as vector analysis, systems layouts (piping, electrical, etc.), graphical mathematics and graphical representation of data, are all part of the system of orthographic projection.

OBJECTIVES

- By verbal or written analyses and by technically correct graphical delineation on daily plates, quizzes and major examinations, be able to:
  - Show thorough comprehension of the *essential features* of orthographic projection.
  - Interpret the meaning of "hinge lines," the labeling thereof and the critical relationships existing between the planes they represent.
  - Demonstrate skill and accuracy both with instruments and freehand, in the mechanics of projection, i.e., items such as parallelism, perpendicularity, proper measurements in relation to planes of projection, and in line quality.



Courtesy of Rising, Almfeldt & DeJong

PRINCIPAL PLANES OF PROJECTION

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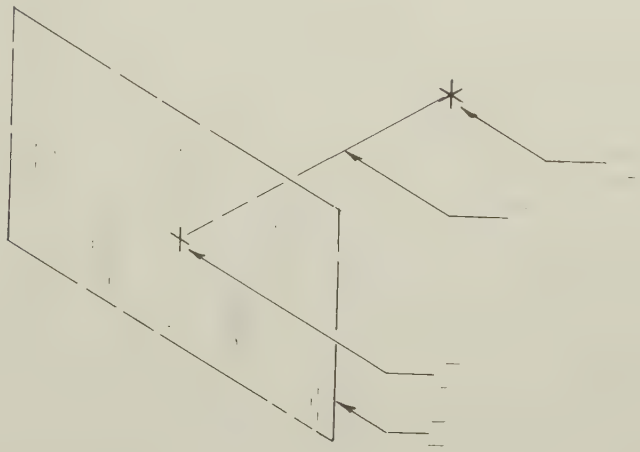
ORTHOGRAPHIC PROJECTION–POINTS

A. Theory of Orthographic Projection

Your future ability with all graphical systems for communicating and problem solving is so dependent on a clear understanding of the principles of orthographic projection that it cannot be overemphasized. Study your text diligently in this truly critical area!

1. At the appropriate places on the given sketch, letter the "four significant features" of orthographic projection.



2. Write a definition of orthographic projection which incorporates the four significant features.

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B. Complete understanding of the hinge line (_____ — — _____) is requisite to understanding the system of orthographic projection. The correct interpretation of any given hinge line is always dependent upon the position of the viewer in relation to the planes or projection at that moment.

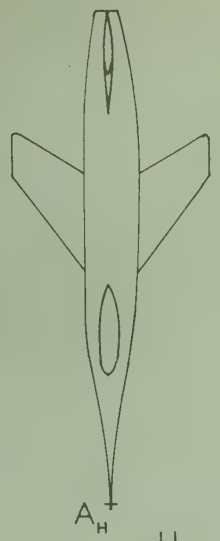
List three different interpretations of what each of the following hinge lines represents. Describe clearly the dependent condition or point of view for making each interpretation valid.

a) H / F

b) H / I

a. 1.
2.
3.

b. 1.
2.
3.



A. Application Problem—Points
Scale: 1" = 1.0"

1. On the given layout locate A_P
2. Locate H, F & P projections of B which is: 2 back of F
   1 below H
   .375 left of P
   & C which is: 2.5 back of F
   .68 below H
   .875 left of P

B. Application Problem—Points
Scale: 1" = 2.0'

1. Locate wall outlet "O" which is:
   on the side wall (P).
   3.5' below the ceiling (H)
   5.0' back of front wall (F)
2. Find ceiling connection "C" which is:
   on the ceiling (H)
   3.0' L of side wall (P)
   2.0' back of F wall (F)

H
F
F
P

The multi-view drawing of the jet fighter plane is a combination of lines drawn between various _____. *Any* point on this drawing will _____ from one view to an adjacent view on straight lines called _____, which in orthographic projection are always _____ to the respective planes of projection. Planes of projection are represented by _____ lines and identified by _____ or _____ that identify the particular plane(s) represented.

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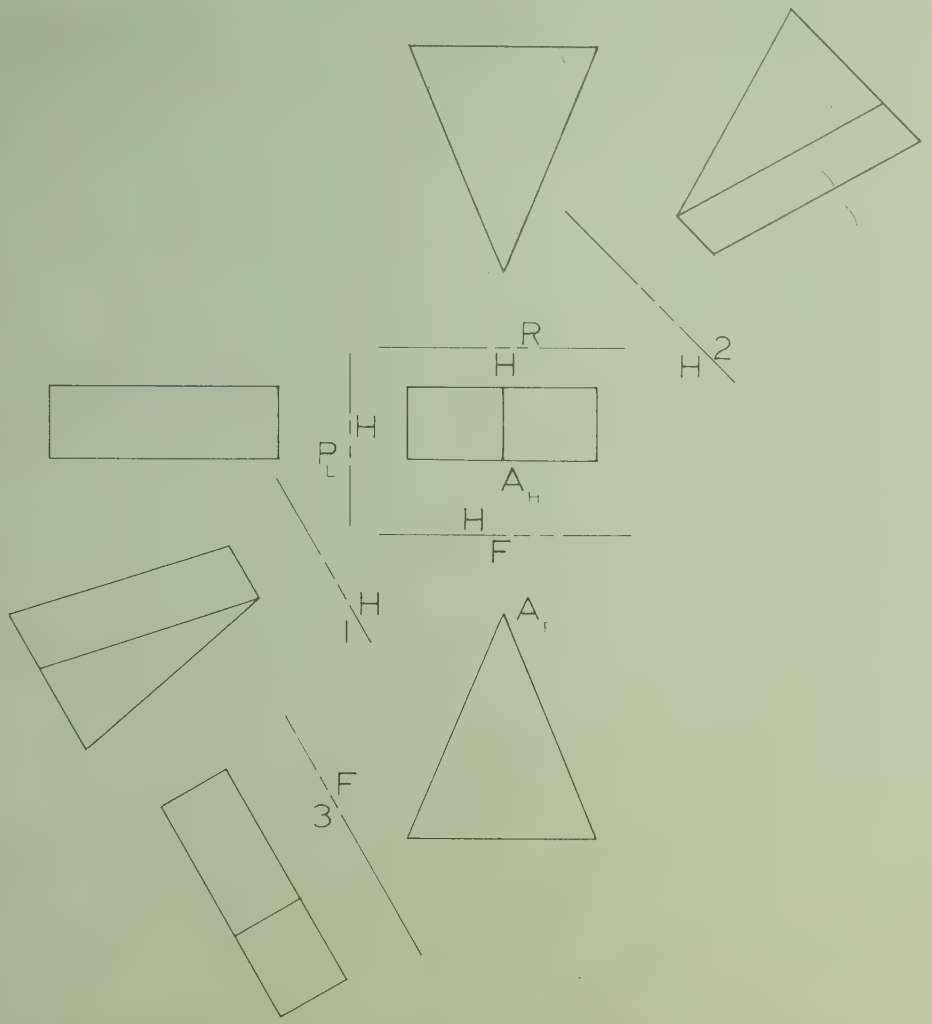
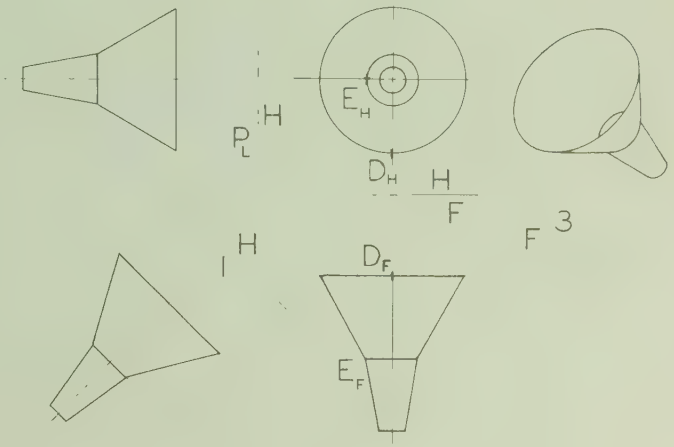
A. 1. Locate and label the projections of point A in all of the given views. (Ratio 1:50, measured in meters.)
2. Point B is located 2 below H, 0.5 behind F and 1.62 to right of P. Project point B into all of the given views and label.
3. Point C is located 2 below H, 1 behind F and 0.37 to right of P. Project point C into all of the given views and label.



B. 1. Locate and label the projections of points D & E in all of the given views.
2. Point G is located on the top rim of the funnel, 3.2" behind F and 4" to right of P. Project point G into all of the given views and label. (Scale: 1" = 4")



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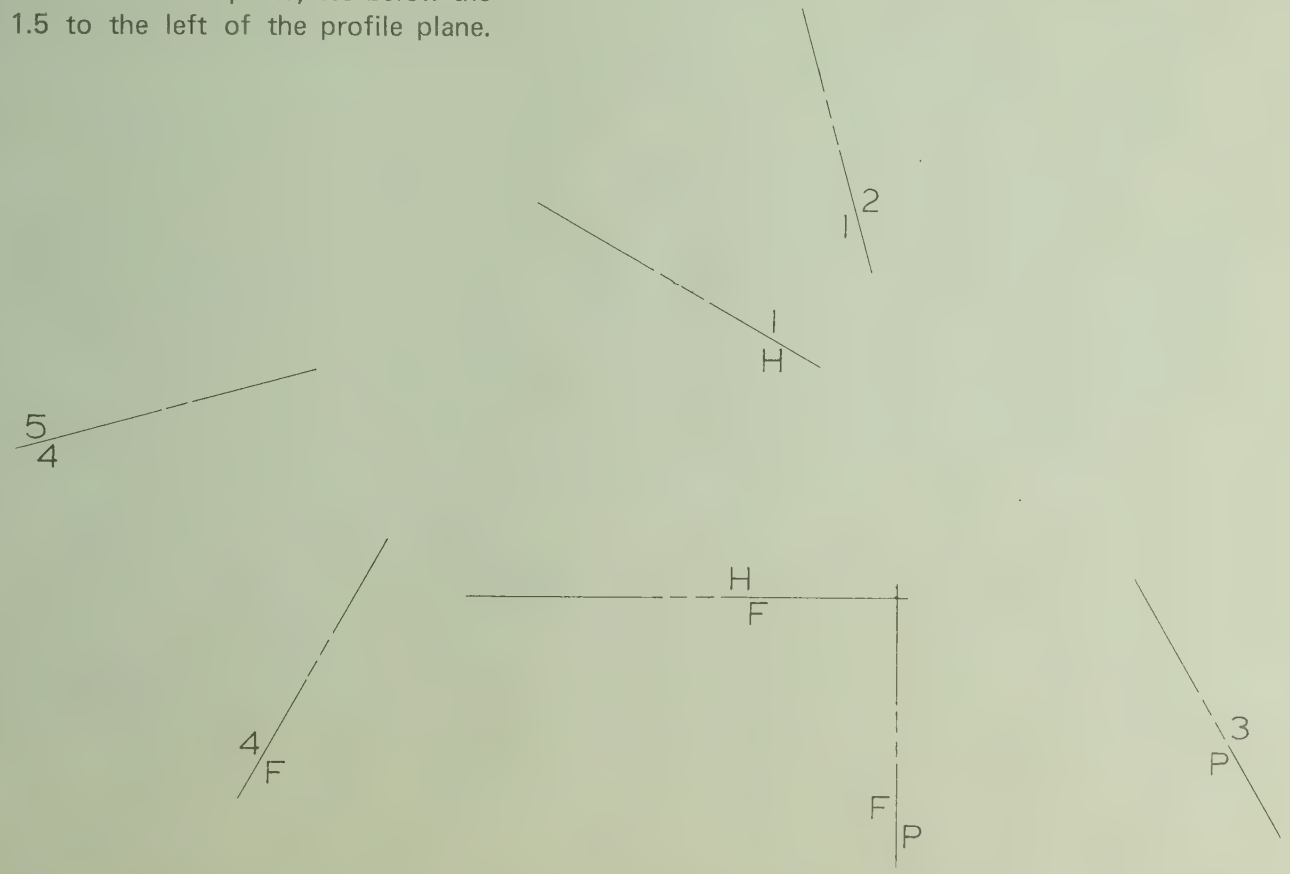
Orthographic Projection—Points

A. Freehand (estimate distances):

B. Instruments:

Show the indicated projections of point V located 0.5 behind the front plane, 1" below the horizontal plane, and 2.25 to the left of the profile plane.

Point T is located 1" behind the front plane, 0.5 below the horizontal plane and 1.5 to the left of the profile plane. (Scale: 1" = 1.0")



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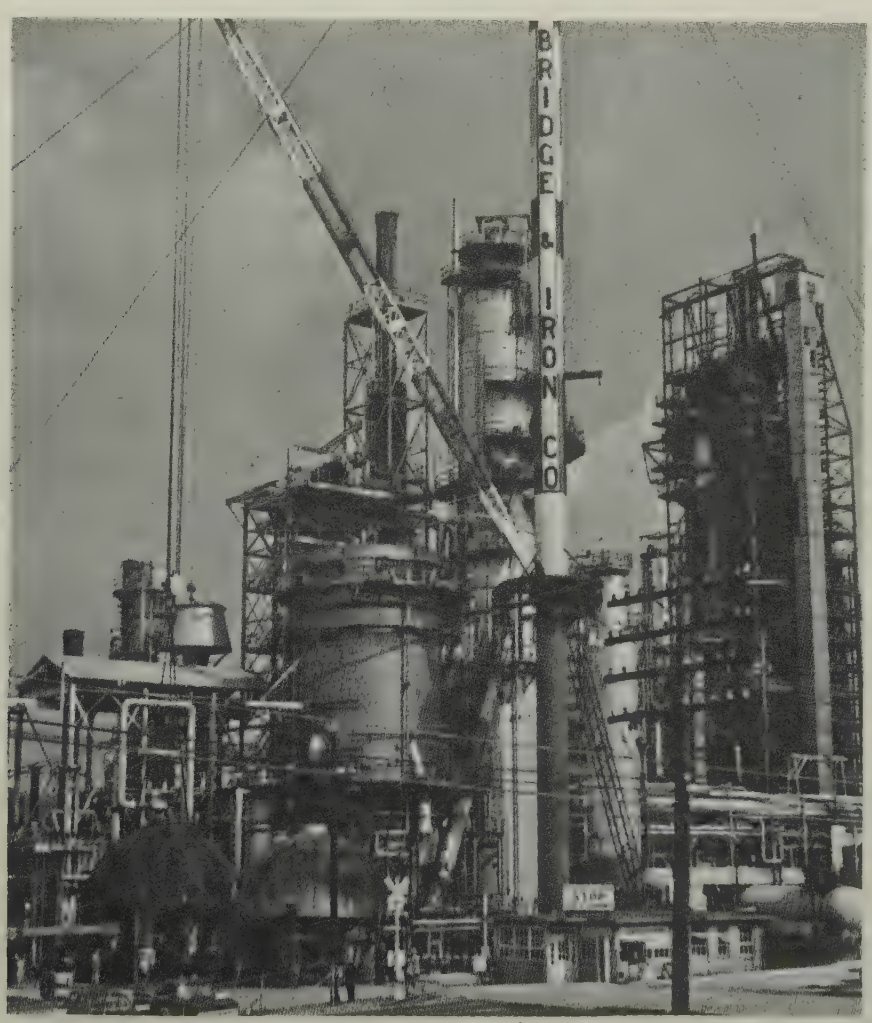
ORTHOGRAPHIC PROJECTION—LINES

USE

- In conjunction with orthographic projection as applied in working drawings.
- Used extensively in vector analysis, systems layouts (piping, electrical, etc.), graphical mathematics and graphical representation of data.
- Used to simulate geometry of clearances, connectors, etc., between wires, pipes and structures.

OBJECTIVES

- To assure the attainment and comprehension of the same general objectives as stated for "Orthographic Projection—Points."
- Specifically, to be able to classify lines in standard terminology and to graphically solve problems involving true length, point view, bearing, slope, etc., and to recognize the implied practical applications of the principles involved.



Courtesy American Bridge & Iron Co.

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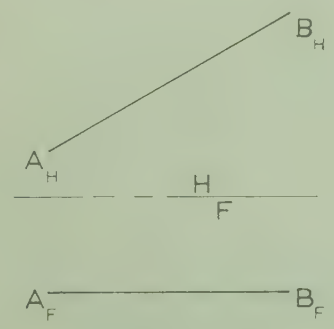
A. Although there are only five (5) classifications of lines in space, there are seven (7) basic positions they may occupy in relation to the principal planes of projection. Five of these positions are given single classifications and two are given double classifications. Complete the following statements of definition.

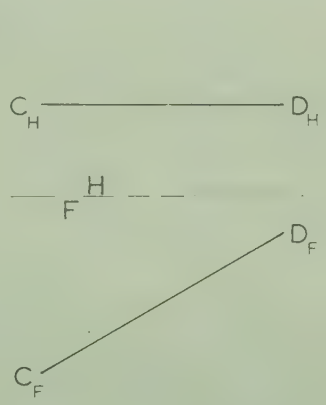
1. A line parallel to the horizontal plane only, is called a _____ line.
2. A line parallel to the front plane only, is called a _____ line.
3. A line parallel to the profile plane only, is called a _____ line.
4. A line parallel to *both* the front and horizontal planes (perpendicular to the profile plane) is called a _____ - _____.
5. A line parallel to *both* the horizontal and profile planes (perpendicular to the front plane) is called a _____ - _____.
6. A line parallel to *both* the front and profile planes (perpendicular to the horizontal plane) might logically be called a _____ - _____ line but is commonly referred to simply as a _____ line.
7. A line oblique (*not* parallel to) the front, horizontal or profile planes is called an _____ line.

B. The seven (7) line positions described in A above are shown as follows. Label the respective classification(s) in the space indicated using abbreviations, H = horizontal; F = frontal; V = vertical; P = profile; O = oblique. Give multiple classification where appropriate.

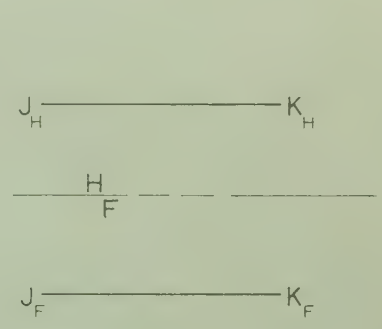
1. _____



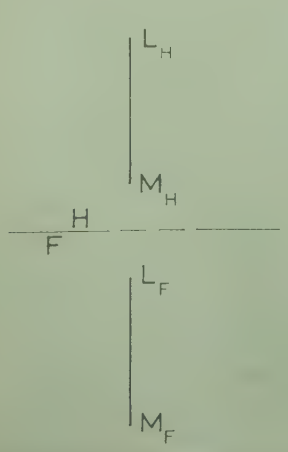
2. _____



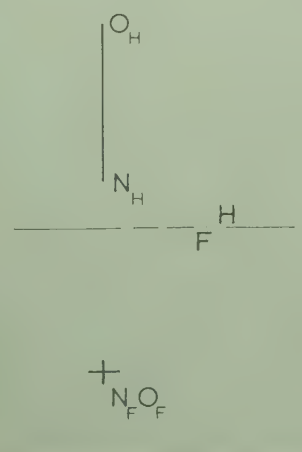
3. _____



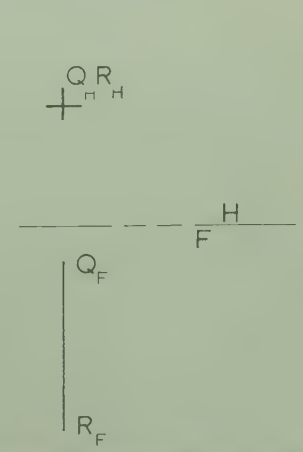
4. _____



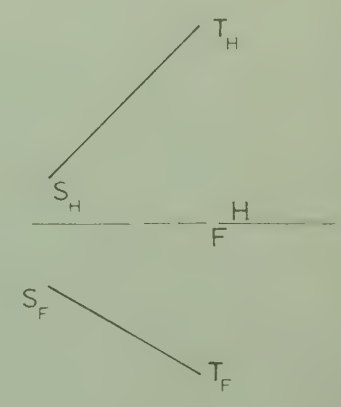
5. _____



6. _____



7. _____



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A. Sketch and label (any appropriate length) the H & F views of the lines indicated.

(Horizontal-Frontal) (Frontal) (Horizontal)

(Oblique) (Horizontal-Profile) (Profile) (Vertical)

B. 1. Write the solution principle for the bearing of a line:

2. Label the bearing of each line in exercise A above.

3. In what view is bearing *always* determined and indicated?

4. Sketch (estimate degrees) the H & F projections of the following:

Horizontal line AB: S30°W;

Oblique line CD: N60°E;

Frontal line JK: Due W;

Profile line LM: Due S;

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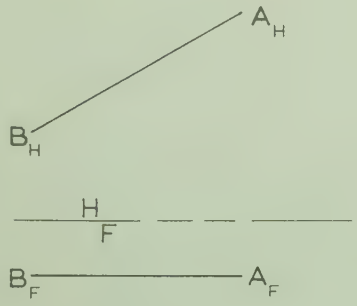
A. 1. Give the solution principle for true length of a line:

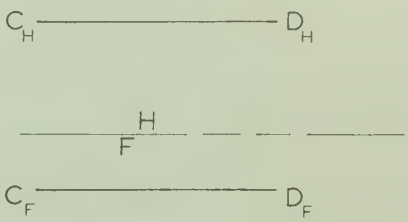
2. Give the solution principle for point view of a line:

B. Classify and determine the bearing, true length (T.L.) and point view of each of the following lines. *Label* bearing and T.L. in the solution view.

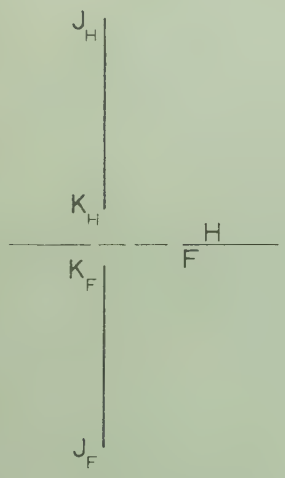
1. (AB) Class: _____



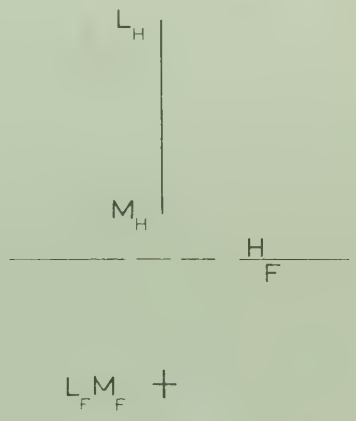
2. (CD) Class: _____



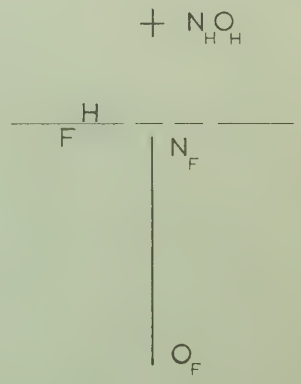
3. (JK) Class: _____



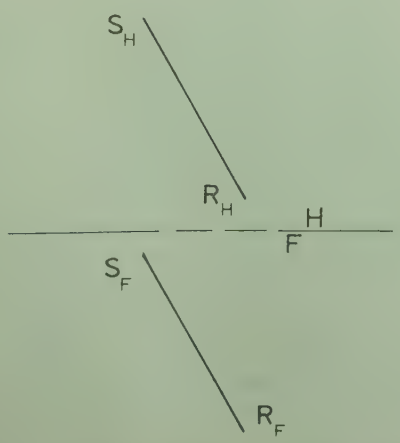
4. (LM) Class: _____



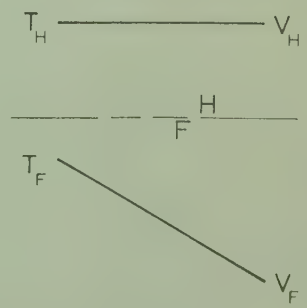
5. (NO) Class: _____



6. (SR) Class: _____



7. (TV) Class: _____

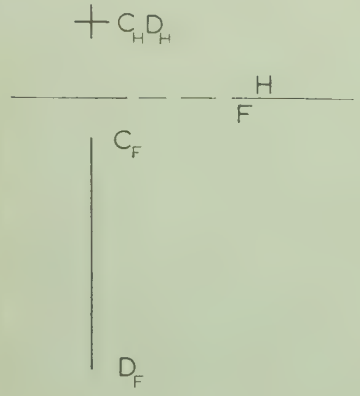


DR. NO.:_ GRADE:

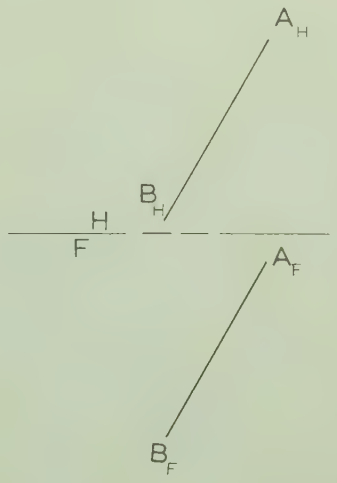
A. Write the solution principle for inclination of a line:

B. Record the classification and (with instruments) determine the bearing; T.L.; slope ∠, slope, or grade; and point view of the following: Label in the solution view.

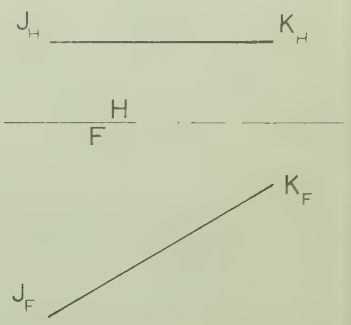
1. (CD) Class: _____
(Grade)



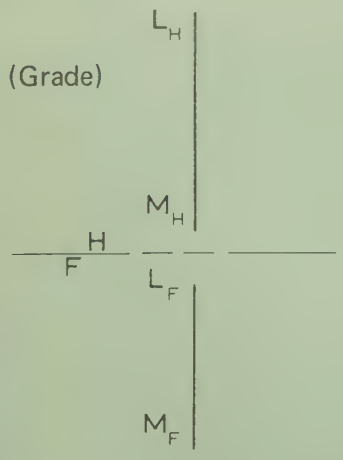
2. (AB) Class: _____
(Slope ∠)



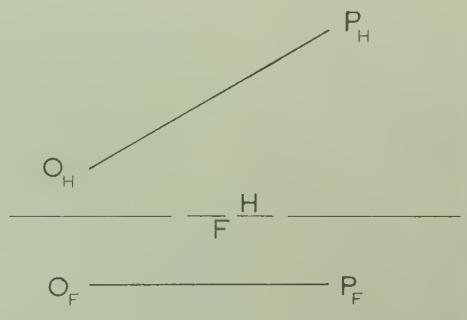
3. (JK) Class: _____
(Slope)



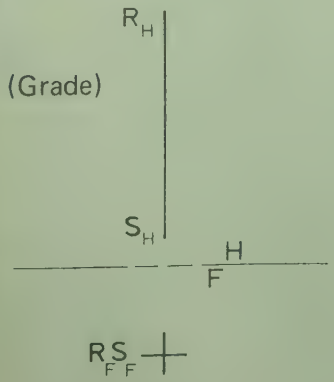
4. (LM) Class: _____
(Grade)



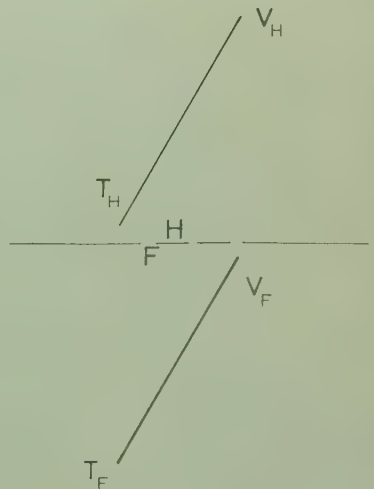
5. (OP) Class: _____
(Slope)



6. (RS) Class: _____
(Grade)



7. (TV) Class: _____
(Slope)



DR. BY:_ INSTRUCTOR:_

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A. State the *solution principle* for inclination of a line:

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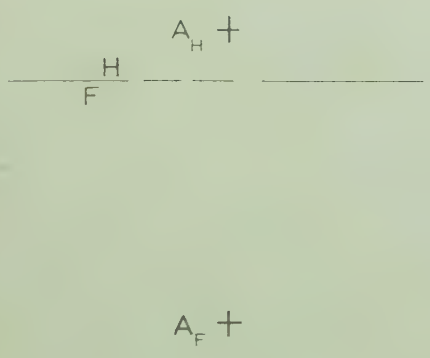
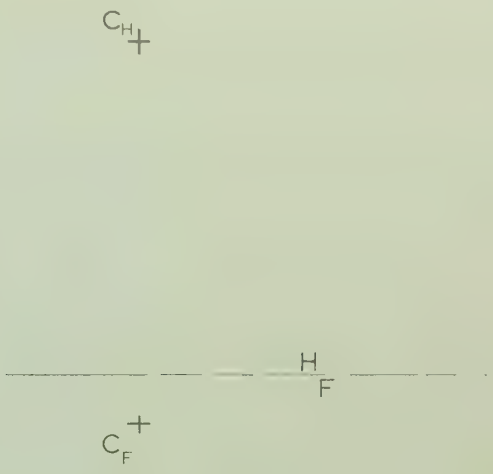
B. With instruments show H & F projections of the respective lines:

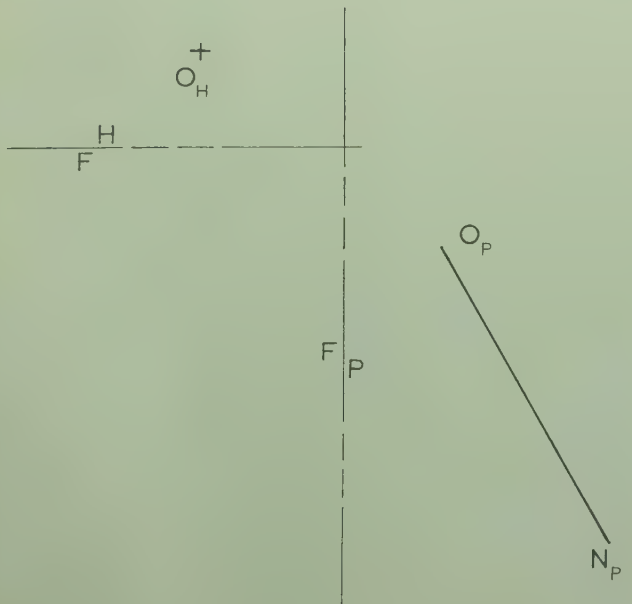
1. Line AB: N30°E; S∠ (+)30°;
   T.L. 22 cm (Scale 1:5) Label.



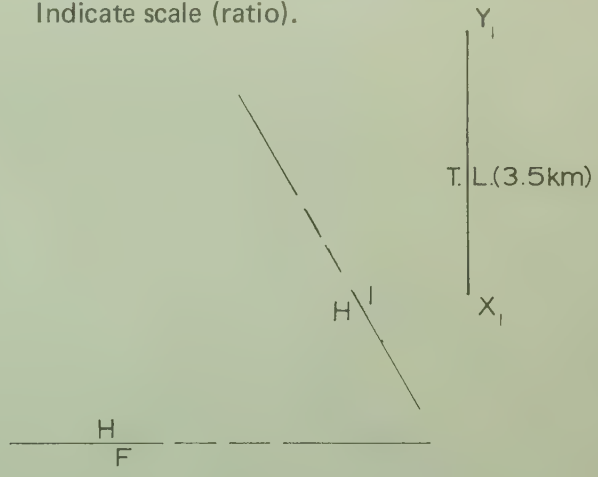
2. Line CD: S30°E; Slope (–)1.3;
   T.L. 180 mm; Scale = 1:4; Label.



3. Profile line NO;
   Determine Grade, Bearing,
   Determine T.L. in mm (Scale 1:2)



4. Show H & F of XY; measure, label grade;
   Indicate scale (ratio).



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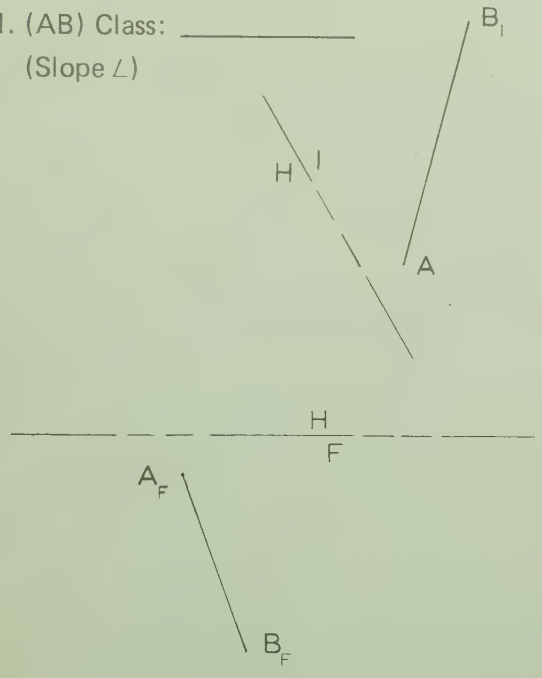
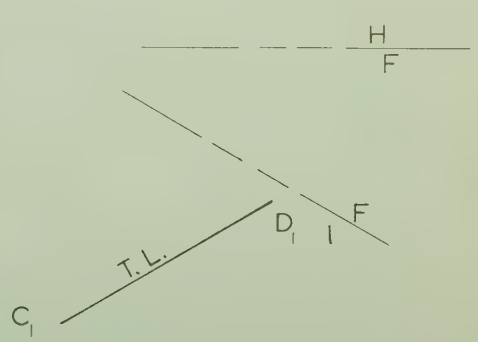
A. To solve the following problems you must apply fundamental *solution principles* involving T.L., point view, bearing and inclination. The information on the problem layout is sufficient to enable the construction of any additional *solution views* needed. Remember, you must progress through *adjacent* views (those having a common hinge line) to obtain a desired solution view, e.g., to progress *from* a given *inclined* view to any desired auxiliary *elevation* view you must project in sequence through the front view, the horizontal view and then to the appropriate auxiliary elevation view (and vice versa).

B. For each problem sketch the H, F and other views required to determine the *classification, bearing,* and *inclination* (slope ∠, slope or grade as indicated). Label on solution view.

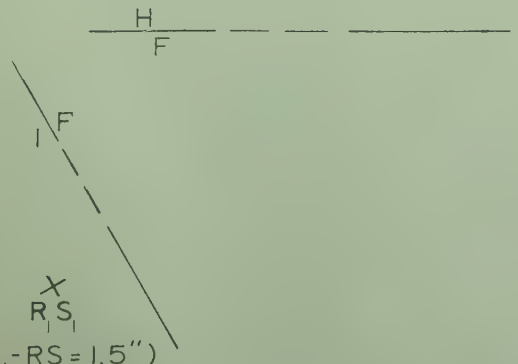
1. (AB) Class: _____
(Slope ∠)



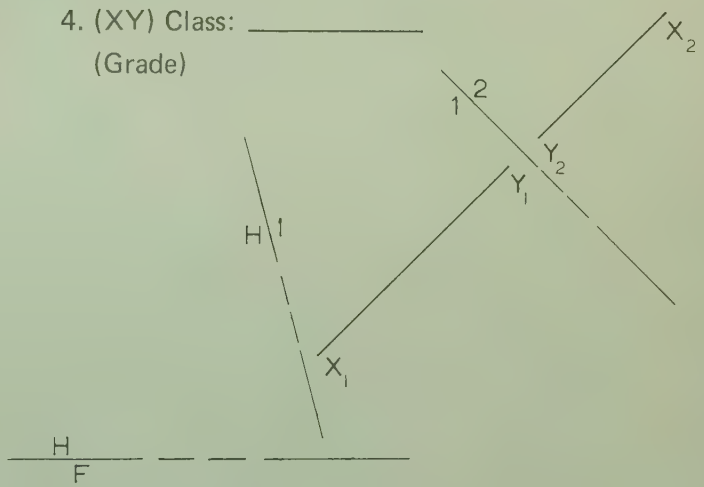
2. (CD) Class: _____
(Slope)



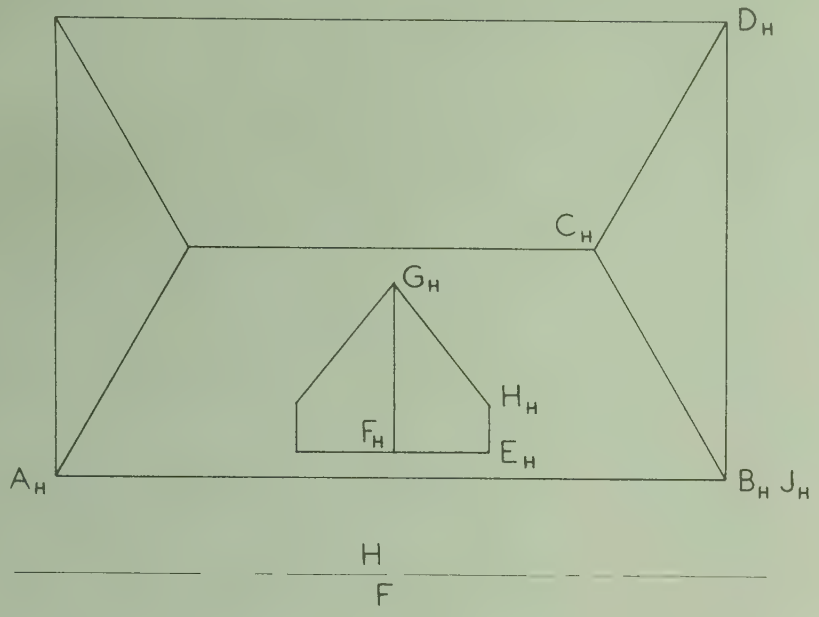
3. (RS) Class: _____
(Grade)



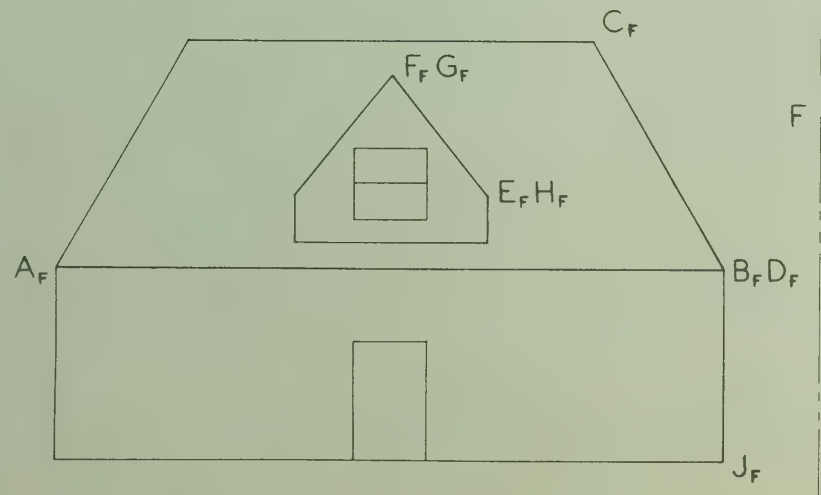
4. (XY) Class: _____
(Grade)

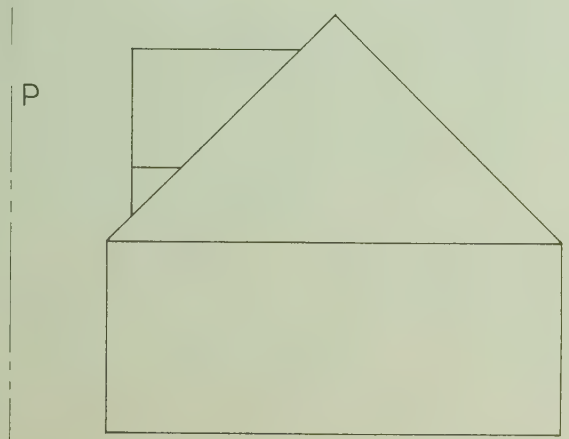


Determine and tabulate the T.L., bearing, and slope of the indicated lines. Scale: 1'' = 5'.



Line	Length	Bearing	Slope
AB			
BC			
EF			
GH			
BD			
BJ			





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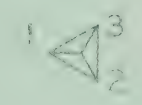
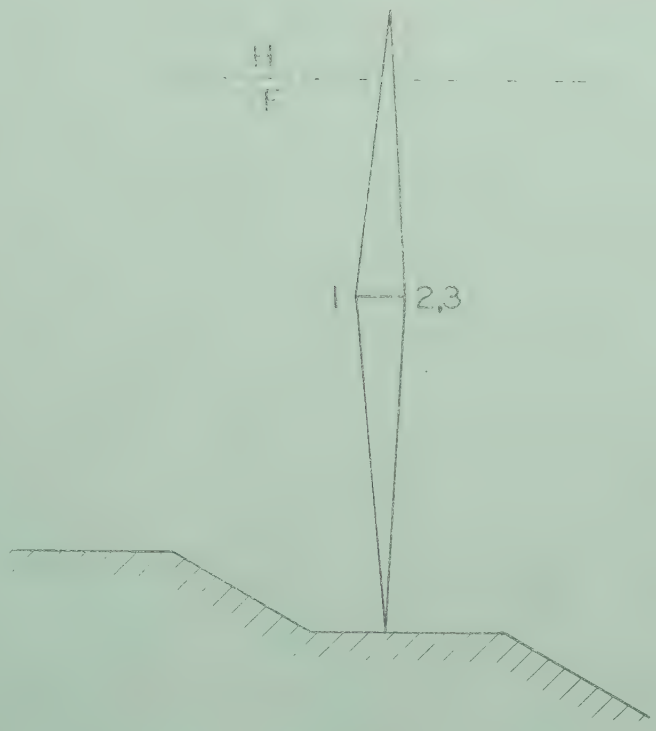




Given: H & F projections of a tower with ground planes shown in the front projection. (Scale: 1" = 40')

A. Find: Length of wire needed for three equally spaced guy wires at (—)45° slope angles from the corners of the structure to the ground.

B. Bearings of the wires will be (1) _____

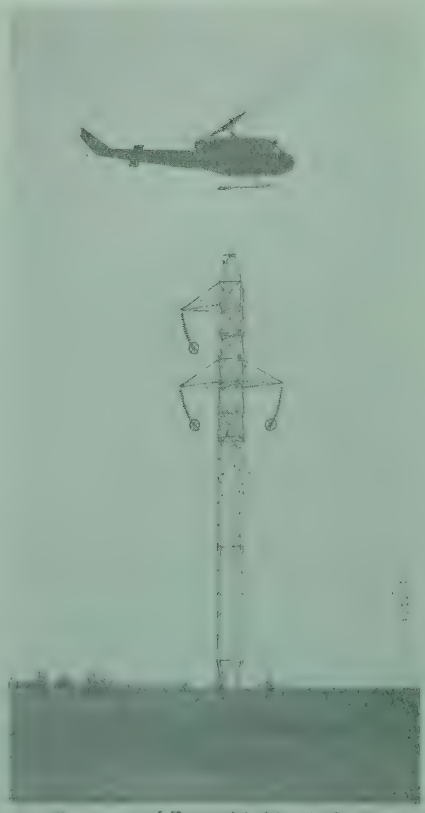
(2) _____ (3) _____

C. The slope angle for guy wire 1 can be shown in T.S. in _____ projection.

D. The slope angle for guy wire 2 (or 3) can be shown in T.S. in _____ projection.

E. The total length of wire to reach the ground is _____.

Note: When the position for the lines has been established graphically, the points where the lines pierce the ground planes can be found by extending the front projections.



Courtesy of Reynolds Metals Company

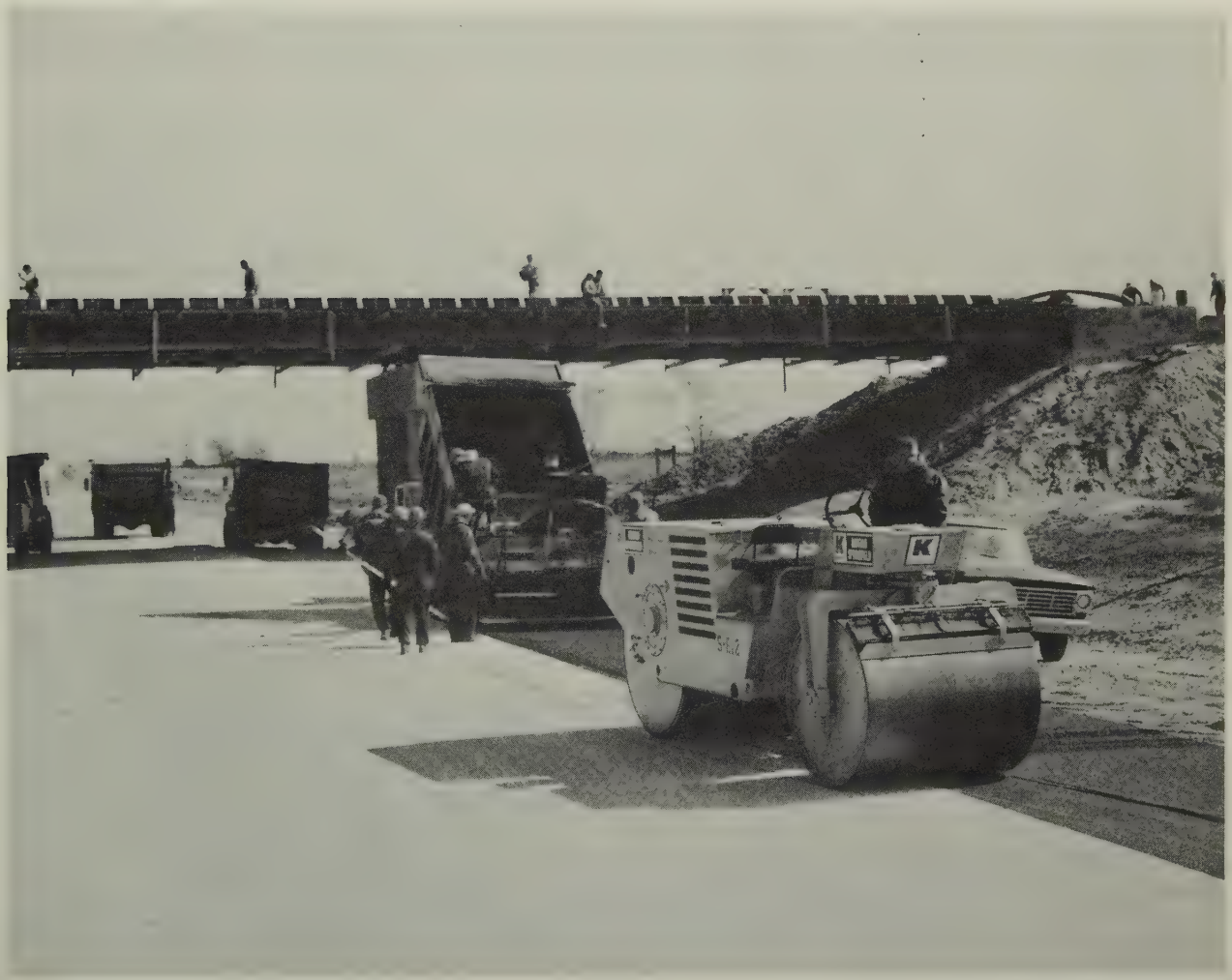
ORTHOGRAPHIC PROJECTION—PLANES

USES

- Without doubt, plane surfaces are the most common found in industry. Basic principles involving planes are universally applicable in all industrial areas.

OBJECTIVES

- General—same as for points and lines.
- Specific—be able to delineate a plane in various ways and to solve problems involving edge view, true size, and how to put a point or line in a plane.



Courtesy Koehring Company

ORTHOGRAPHIC PROJECTION—PLANES

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DR. NO.

GRADE:

A. *Importance*: Plane surfaces or combinations thereof, are without question the most common and useful surfaces found in industry. Obviously an engineer should be thoroughly familiar with the nature and value of this most important surface.

B. Definition, Representation, Specifications, Classifications. *After* carefully lettering the missing words in the following exercises, check your answers with those given on the back of this sheet.

1. *Definition:* A flat, _____ dimensional area that wholly contains every _____ line joining any _____ points in it. Whereas a *line segment* is any finite (measurable) *portion* of a theoretical line of infinite length a _____ *sector* is any _____ portion of a theoretical plane of _____ area.

2. *Graphical Representation:* The graphical delineation of a plane *sector* can take any conceivable two dimensional shape, i.e., two intersecting _____ lines, two _____ straight lines, _____ points not in a straight line, a straight line and a _____ not on the line. A circle, ellipse, irregular curve, triangle, square or any polygon or any combination of the aforementioned shapes may be finite plane _____ if they meet the specifications of a plane as previously defined.

3. Just as the position of a line of infinite length can be described by any segment of that line, so does a _____ fix the position of a plane of infinite area.

4. The number of theoretical planes through any point in space is _____.

5. A given plane _____ may be altered in shape or extended in area without changing the _____ of the plane in space.

6. The number of new points or lines that can be added to the given graphical representation of a plane sector without changing the _____ of the plane in space is _____. However, any such points or lines added to a plane must be _____ on the flat _____ defined by the original position.

7. A *point* located on any _____ lying wholly within a plane is also in the _____. A straight line connecting any _____ points in a given plane is also in the plane.

8. A point or line may lie *in a plane* without being in the given _____ of that plane.

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B. 1. two
straight, two
plane, finite, infinite

3. plane sector

2. straight, parallel
three, point
sector

4. infinite

6. position, infinite
wholly, surface

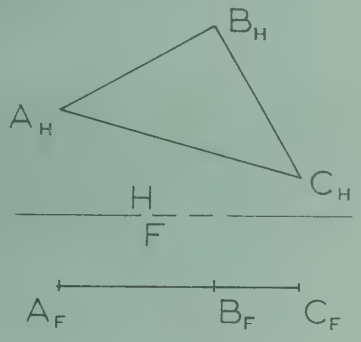
5. sector, position

7. line, plane
two

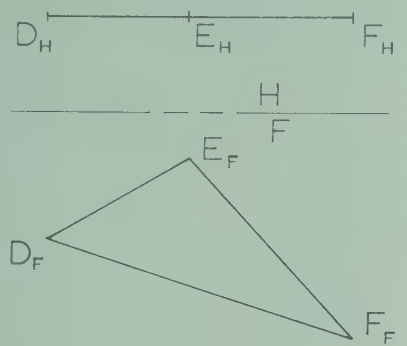
8. sector

ORTHOGRAPHIC PROJECTION–PLANES

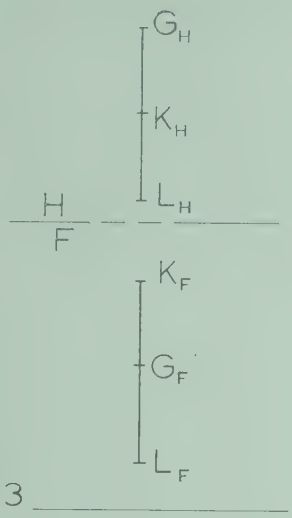
A. Classify each of the planes. Mark T.S. on views showing the true size projection of the plane.



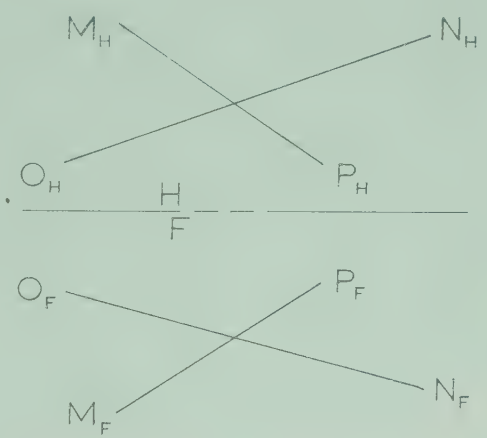
1 _____



2 _____

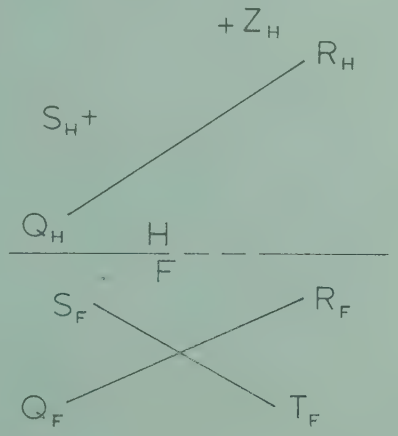


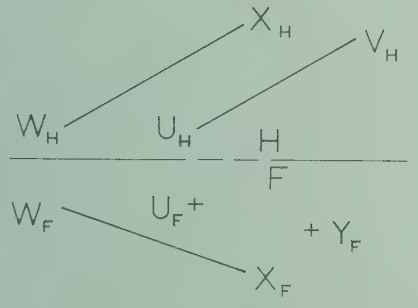
3 _____

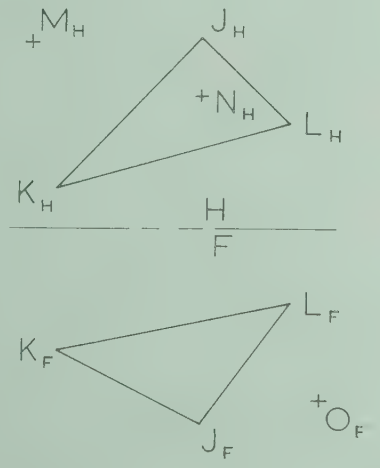


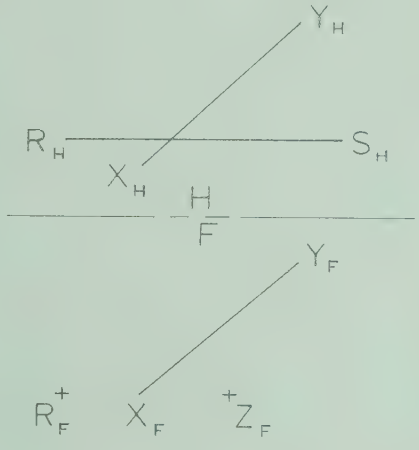
4 _____

B. Complete (freehand) the views of the planes. All indicated points are on the plane in each exercise.









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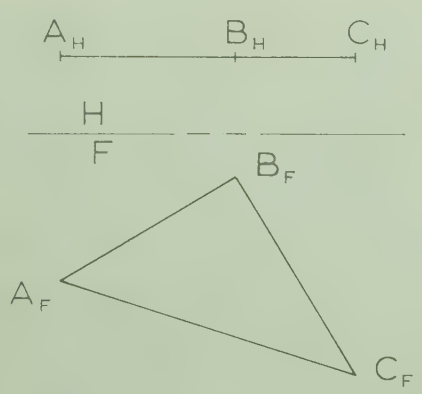
ORTHOGRAPHIC PROJECTION—PLANES

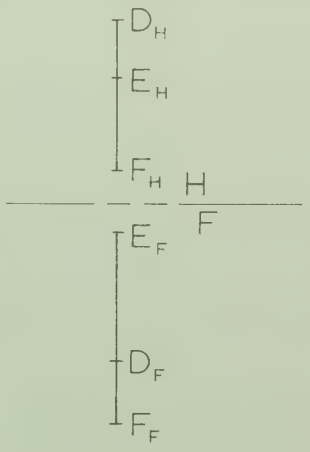
A. Write the solution principle for the true shape of a plane.

B. Find and label the true shape of each plane. Indicate the classification of each plane.

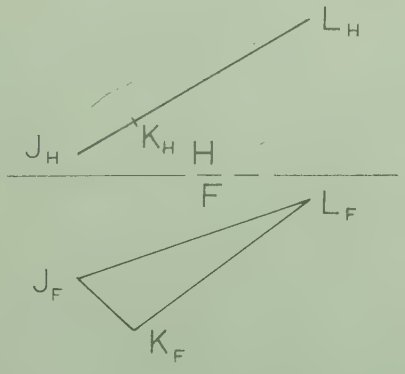
1. _____



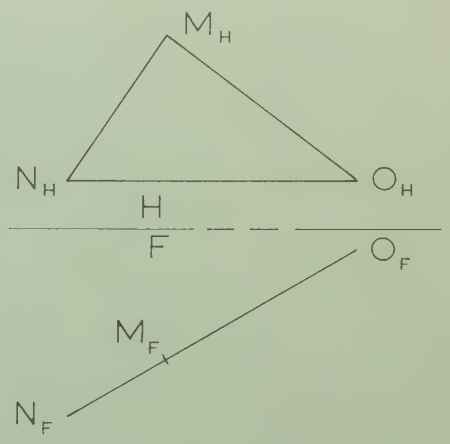
2. _____



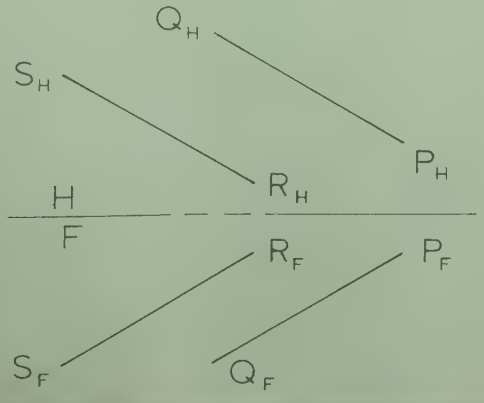
3. _____



4. _____



5. _____



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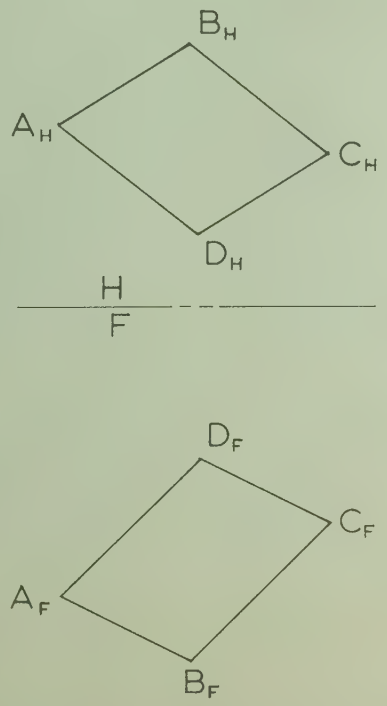
ORTHOGRAPHIC PROJECTION—PLANES

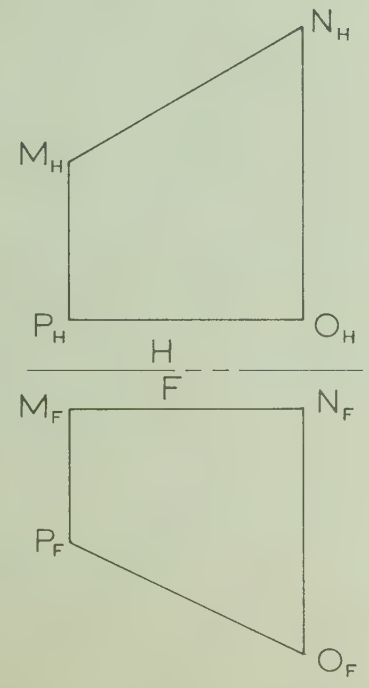
A. Sector ABCD is the surface of a steel plate, 10 mm thick, used in a construction project. Scale: 1:50

1. Determine the slope angle of this sector.
2. Determine the weight of the plate. (Steel weighs 7860 kg/m^3)

B. One segment of a chemical mixing tank is represented by plane sector MNOP. Scale: 1:10

1. Determine the slope angle.
2. Determine the area in square meters.





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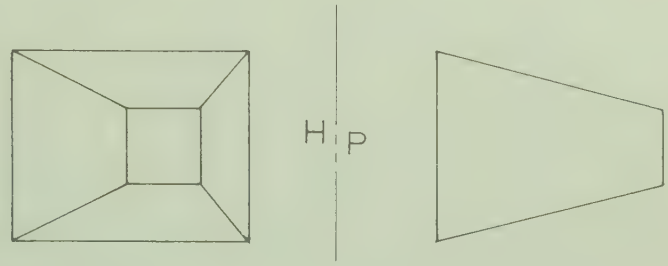
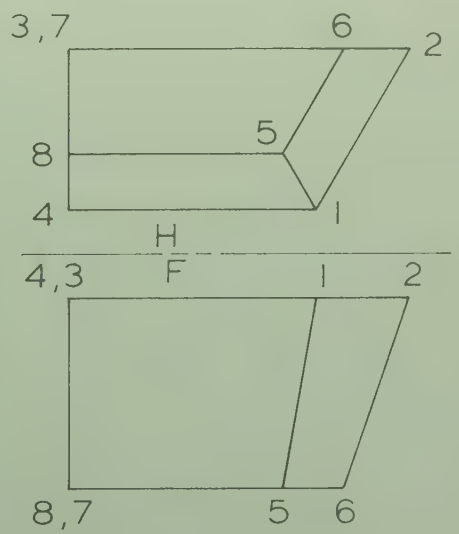
ORTHOGRAPHIC PROJECTION—PLANES

A. Find the true size of each side of the Hopper. Scale: 1:40



B. Find the true size of each side of the storage tank. Scale: 1:20



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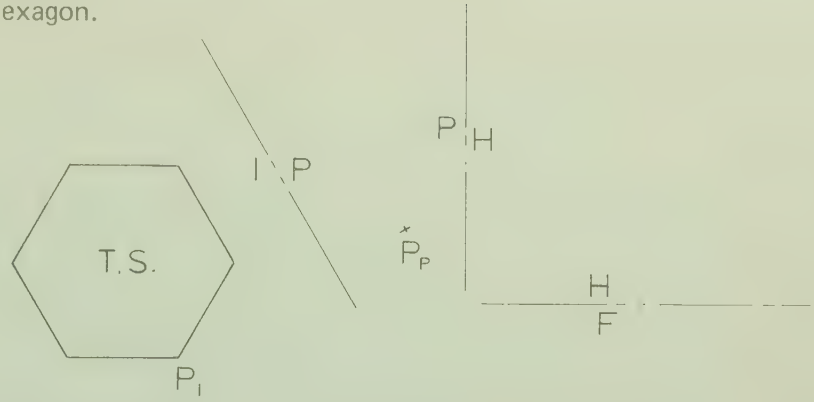
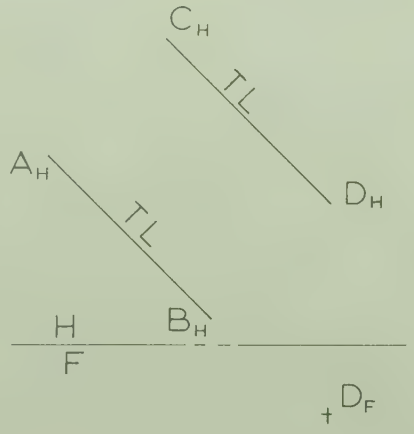
ORTHOGRAPHIC PROJECTION—PLANES

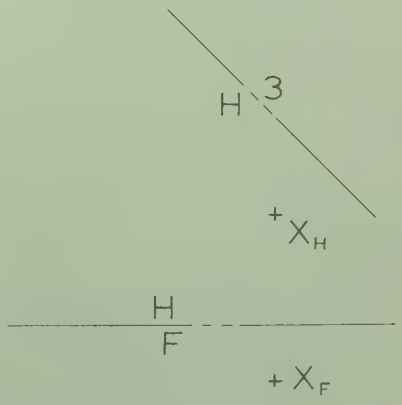
A. Find the H & F views of the hexagon.





B. AB & CD lie in a plane whose slope angle is 30°. AB is lower than CD. Find the TS of ABCD and project into front view.

C. Equilateral triangle (T.S.) XYZ appears as an edge in plane 3 with a slope angle of 30° sloping downward to the NW. Line XY is parallel to plane 3 and is 3 cm long.



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PROBLEM SOLUTIONS BY ROTATION (PLANES)

A. Use a plastic triangle as a model. Hold it at eye level and obliquely to your line of sight (a "front" view). Place a pencil in a horizontal position on the surface of the model and slowly rotate the model about a vertical axis until the point view of the pencil projects perpendicular to the "front" plane.

1. You now see the _____ view of the plane in the front view.

Now rotate the model about a horizontal axis (seen as a point in the front view) until the triangle is in a horizontal position.

2. The T.S. of the plane is now seen in the _____ view.

3. The procedure to get the T.S. of the plane was to first put a _____ line in the plane, then _____ the plane until the horizontal line was _____ _____ to the front plane. This showed the horizontal line as a _____ and the plane as an _____. You then rotated the plane about a _____ seen as a point in the _____ view until the plane was _____. It then would project _____ _____ in the _____ view.

B. Use the same model as before but this time position your line of sight vertically (a "horizontal" view.) Imagine a "front" plane of projection properly oriented to your H view. Place a pencil on the surface of the plane in a frontal position. Establish an imaginary horizontal axis of rotation perpendicular to the F plane. Slowly rotate the model around this axis until you see the point view of the pencil.

1. The plane now projects as an _____ in the H view.

Try this again and note if the perpendicular distance from any point on the triangle to the F plane changes as you rotate the model.

2. The perpendicular distance to the F plane (does) (does not) vary. The projected distance between various points on the triangle as viewed in the H projection (does) (does not) vary.
3. What principles (by number) in your text are applied in the front view you assumed above?

Position your model in a vertical position. Establish a vertical axis through the edge view of the plane and slowly rotate the model to a position parallel to the F plane.

4. The plane (triangle) will project in T.S. in the _____ view.

A. 1. edge

3. horizontal
rotate
perpendicular
point
edge
horizontal axis
front
horizontal (level)
true size, horizontal

2. horizontal

B. 1. edge

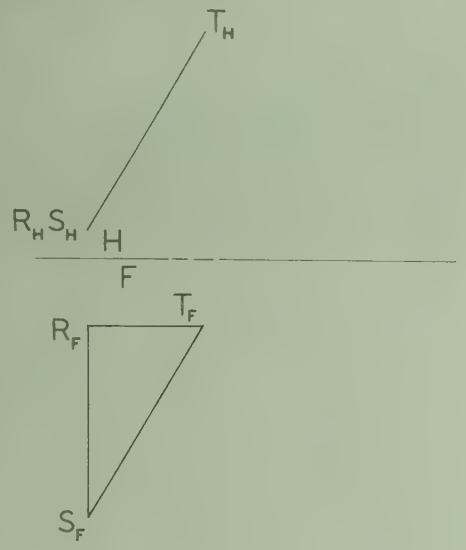
3. (look them up)

2. (does not) (does)

4. front

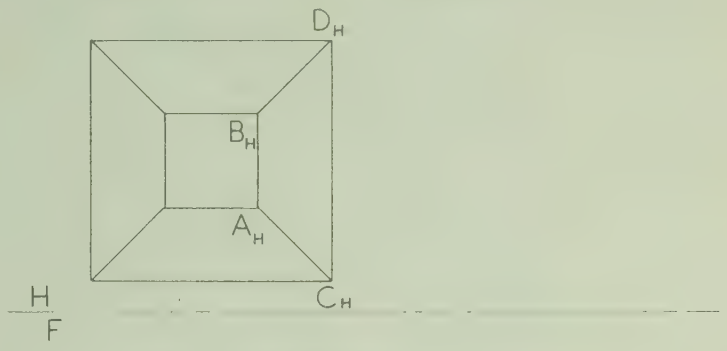
ORTHOGRAPHIC PROJECTION—PLANES

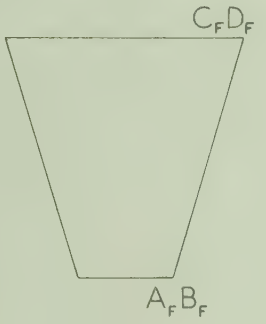
A. Show a true size projection of plane RST and determine its area.
Scale: 1″ = 5.0′



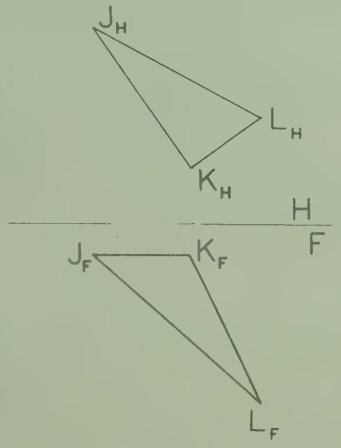
B. The horizontal and front projections of a sheet metal hopper are given. Scale: 1″ = 4.0′

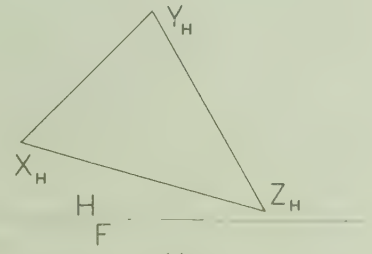
1. Find the true size view of side ABCD.
2. Show the horizontal, front and true size views of a 1.5′ square hole located with one of its sides parallel to and 2.0′ from AB.

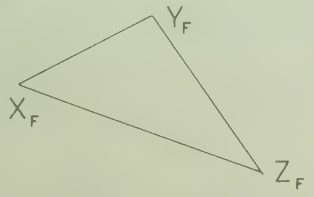




C. Determine the slope angle of plane JKL.







D. Determine the slope angle and show the true size projection of plane XYZ.

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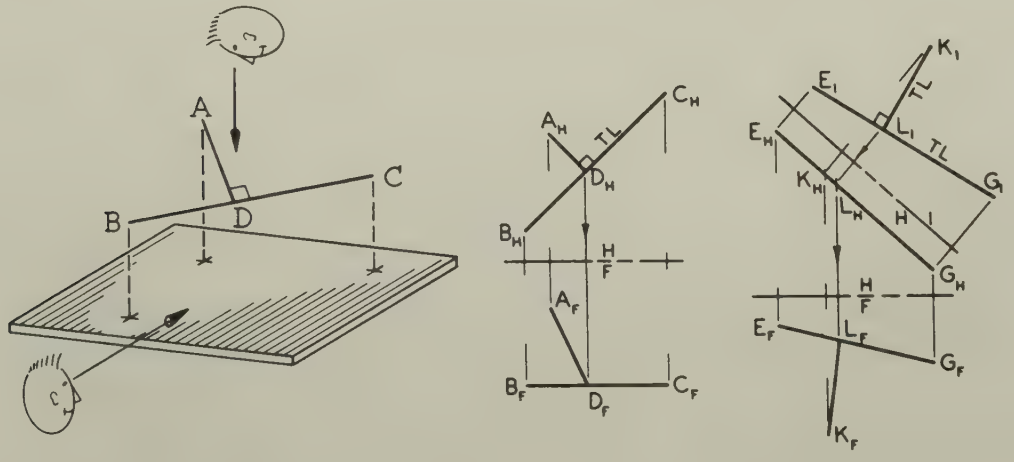
SPACE GEOMETRY—POINTS AND LINES

USE

- The practical applications of the geometric relationships between points and lines are mainly in the area of clearance problems. The clearance may need to be determined between some critical point on a machine or structure and nearby transmission lines, piping systems, sewer lines, or structural members. The use of this type problem as a stimulant for developing man's intellect (visualization, sequential thinking, concentration, engineering method, etc.) is rarely questioned by thoughtful engineering educators.

OBJECTIVES

- To develop sequential thinking, analysis patterns and spatial visualization concepts.
- To solve problems of a theoretical nature and comprehend their practical applications in industry.
- To perform orthographic manuevers for viewing points and lines that will be used in conjunction with solving more complex problems involving lines and planes.
- To readily solve problems graphically involving the clearance or perpendicular connector from a point to a line and the fundamentals of the geometry involved.
- To solve connector and clearance problems of all types involving nonparallel, nonintersecting lines.



PRINCIPLES OF PERPENDICULARITY

DR. NO.__ GRADE:

Study Principle of Perpendicularity. (Text)
Set your dividers or compass so that the angle between the legs is 90° (i.e. locked perpendicular to each other). Position the instrument a short distance from you at eye level so that one of its legs is vertical, the other horizontal—both viewed in T.L. from your line of sight. Study the view, then fill in or underline correct answers.

A. The projected view of the angle is _____ degrees.

B. Keeping one leg vertical (T.L. view) while rotating the other leg backward or forward one fourth turn or more—the projected angle to the viewer is _____ degrees.

C. Keeping one leg horizontal (T.L. view) while rotating the other—the projected angle to the viewer is _____ degrees.

D. Incline the instrument at about 30° from horizontal so that *both* legs point away from you obliquely. The actual 90° angle now projects at: 90°; more than 90°; less than 90°.

E. Position the instrument in a vertical plane with the handle as a vertical axis of rotation. Rotate one leg back, the other forward. The projected angle to the viewer is now 90°; more than 90°; less than 90°.

F. Complete this theorem: If two lines are perpendicular to each other they will project at _____ angles in any orthographic view where _____ or _____ of the lines project true length.

G. In an orthographic view where *neither* of two lines that are perpendicular to each other projects in true length, the projected angle between them will be other than _____ degrees.

H. In orthographic views a line may (sometimes) (never) project longer than its true length.

I. An angle (may) (may not) project larger than its true size.

J. An angle (may) (may not) project smaller than its true size.

Note: In the actual orthographic solution of problems involving perpendicular connectors the principles of perpendicularity just described are critical. Understand these principles, review them frequently and apply them when needed.

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ANSWERS–42

A. 90

C. 90

B. 90

E. less than 90°

D. more than 90°

F. right, either, both

H. never

G. 90

J. may

I. may

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SELF INSTRUCTION—BASIC PRINCIPLES

A. Clearance—Perpendicular connector, Point to a Line, Method 1.
The shortest distance between a point and a given straight line is on a connecting straight line that is perpendicular to the given line.
This *distance* is often referred to as *clearance.*
The *line* indicating this distance is referred to as the *perpendicular* (or *shortest*) *connector.*
With one hand hold a pencil in a vertical position at eye level. Position the tip of the index finger of your other hand at the same height and distance from your eyes at the middle of the pencil and 3 or 4 inches from the pencil. Study this relationship a few seconds and complete the following.

1. A concise phrase describing the shortest possible *line* between the tip of your index finger and the pencil would be: connecting _____ line _____ to the pencil.

2. The shortest *distance* from the tip of your index finger to the pencil might also be properly referred to as _____.

Now, with one hand, position the pencil so that you have an end view (point view) of it. Hold the tip of the index finger of your free hand three or four inches perpendicularly away from the pencil. Holding the point view of the pencil as an axis of rotation slowly move your finger tip in a circular arc around the pencil. Study this relationship. Note that a perpendicular line *(shortest connector)* from your finger tip to the pencil would always project T.L. to the viewer. This observation should help you visualize a proven solution principle for determining the shortest connector or clearance from a point to a line. See if you can complete the partial analysis given below:

3. Obtain that view of the line and the point, where the _____ will project as a _____. The *shortest connector* or *clearance* will *always* project in _____ in such a view.

4. Are there connectors *other than* the perpendicular connector in the view described above? Yes, No.
Do they project in true length in this view? Yes, No.

B. Clearance—Connector, Point to a Line—Method 2.
Again, hold a pencil in a vertical position at eye level, the tip of the index finger of your other hand at the same height and distance from your eyes as the middle of the pencil and 3 or 4 inches from the pencil. Can you identify a plane comprised of the pencil and a point on your finger tip? Assuming you can—answer the following:

1. Does the shortest connector from your finger to the line lie in this plane? Yes; No.
2. Does this perpendicular connector just described show in T.L.? Yes; No.
3. If you obtained the *true size* view of the plane defined above, would that view show the perpendicular (true length) connector? Yes; No.

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A. 1. yes (hopefully)

3. yes

2. 90

5. yes (hopefully), true length

4. Yes, No

B. 1. plane, lines, parallel

3. plane, parallel

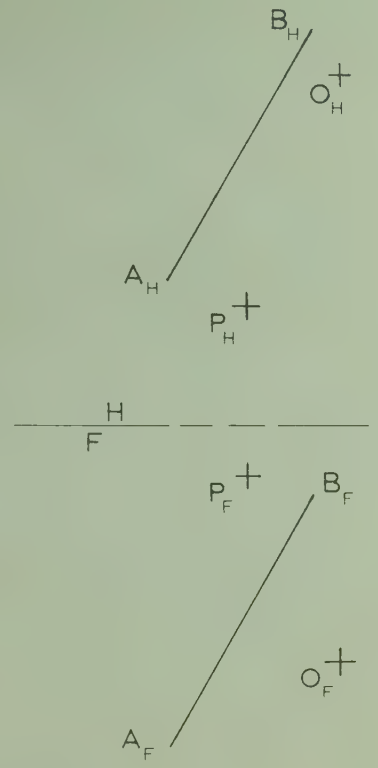
2. parallel

4. parallel, the second

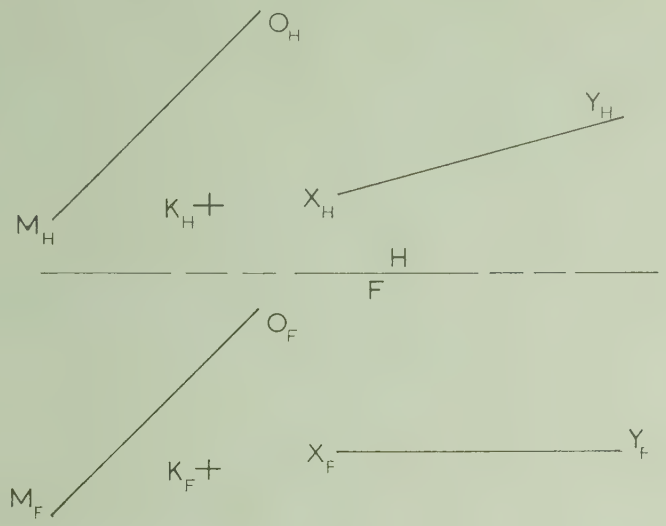
6. point, perpendicular

5. an edge
parallel
true length

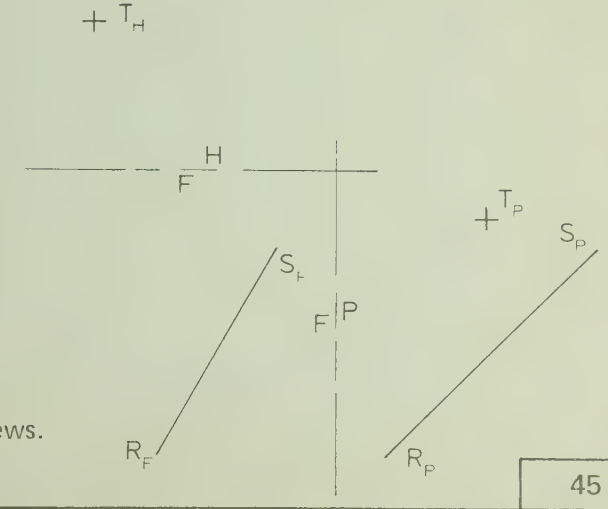
A. Locate the shortest connectors in all views.



B. Determine which is shorter—the perpendicular connector from K to MO or the one from K to XY (show connector in all views).



C. Locate the shortest connector in all views.



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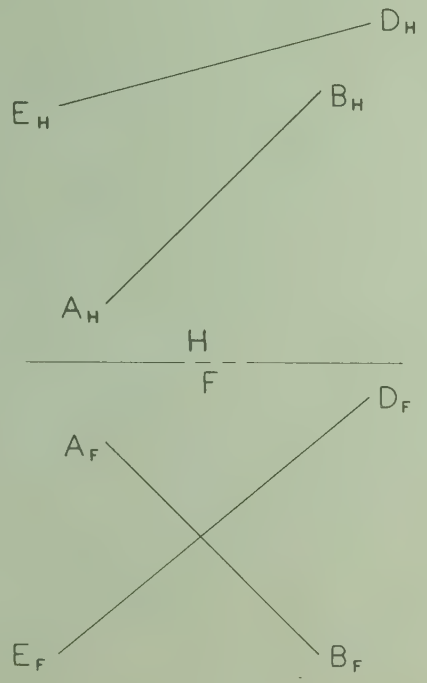
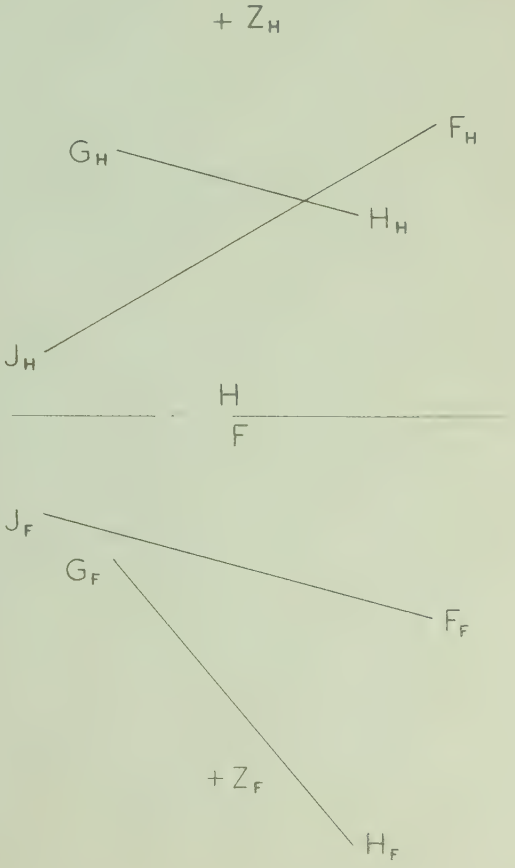
A. Using just the H and F views, draw a plane ABC that contains line AB and is parallel to line DE. Prove your solution by an auxiliary elevation view.



B. Using just the H and F views, draw a plane XYZ containing point Z and parallel to both lines JF and GH. Prove your solution by an auxiliary elevation view.



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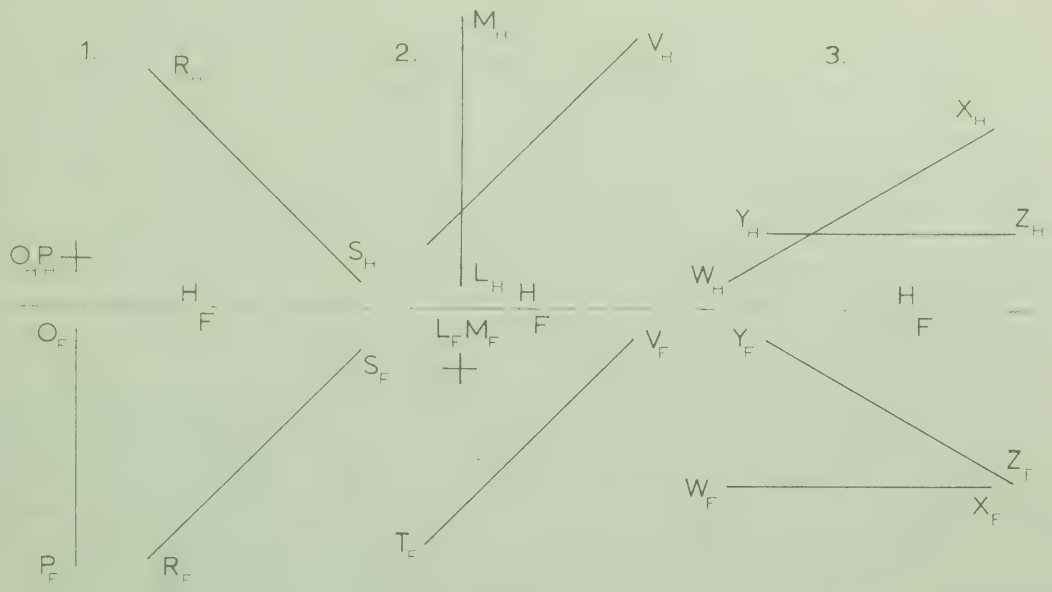
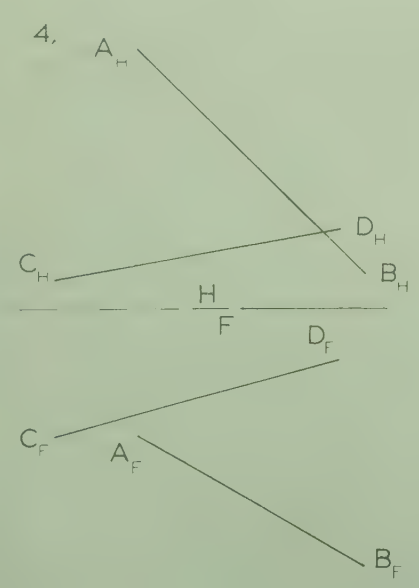
A. Show the vertical (if one is possible) and the perpendicular connectors in each view.

B. Classify, label and give the bearing and slope ∠ of each of the connectors found in A.





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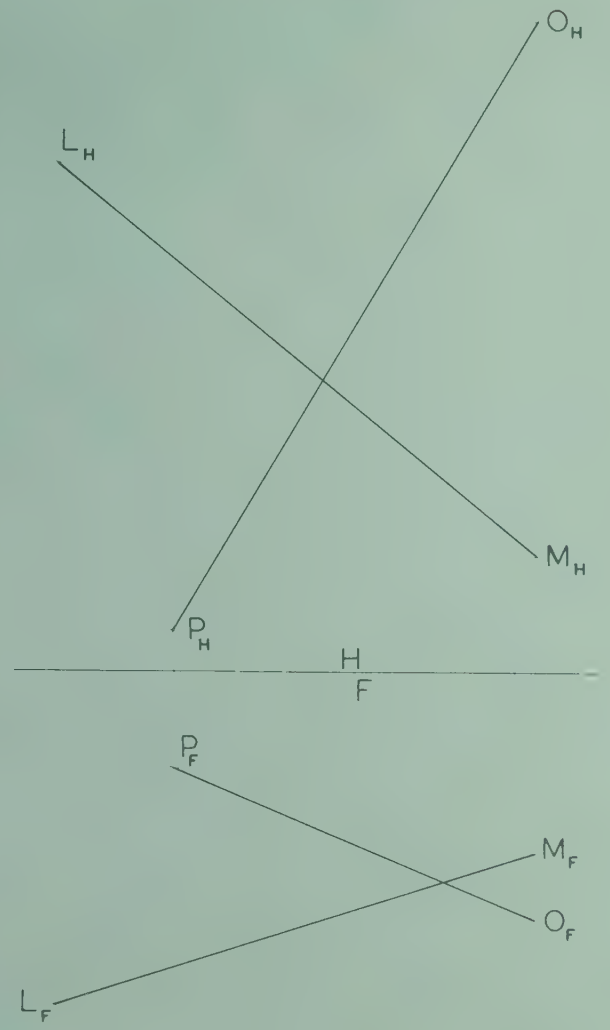
A. Show the vertical and perpendicular connectors in all views and label and record the classification, bearing and grade of each.

B. Show the shortest 50% grade, the shortest horizontal, the perpendicular and the vertical connectors in all views.



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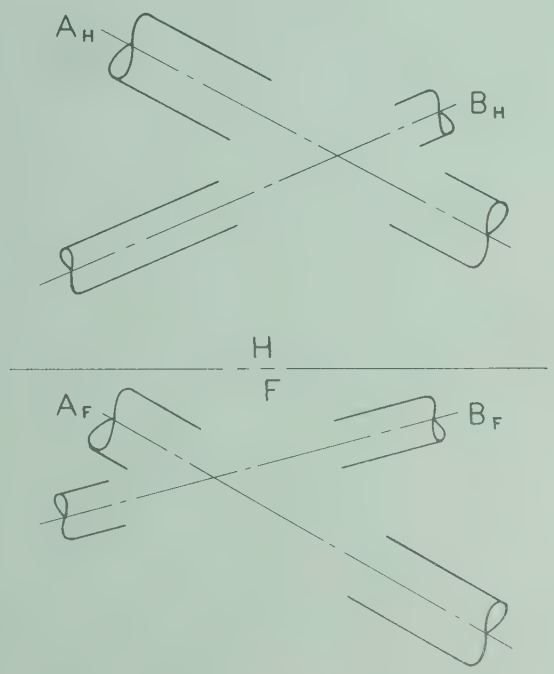
Determine the clearance between the two pipes. Draw a line that would connect the two pipes at their closest point, and project into H & F views. Complete the H & F views with proper visibility. Scale: 1″ = 4″. Clearance _____ .

Courtesy Todd & Sargent



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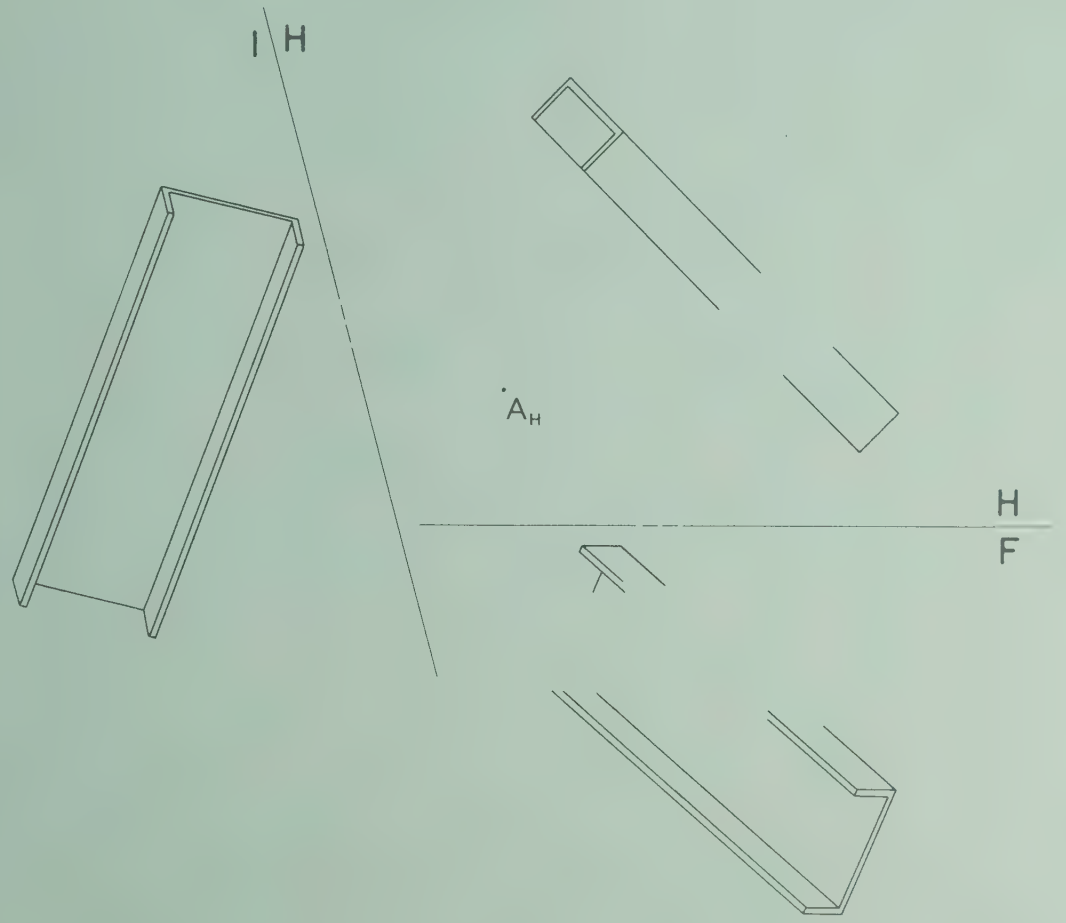
The location of a portion of a structural channel for a proposed hangar is shown. A level 3 X 3 X 0.4 angle iron strut has its corner passing through Point A bearing N75°E. Determine the lowest position of the angle which has one face parallel to the axis of the channel and passes above the channel with a one inch clearance. Scale: 1" = 6". Show the plan and elevation views of the angle iron with proper visibility.



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SPATIAL GEOMETRY—POINTS AND LINES

A. The shortest possible connection is to be made from a point S to a pipe HJ which bears due N from H. Point J is 10 feet due N of H and 8′ higher than H and point S is 6′ due east of H and on the same elevation as J. Show the connector in all views. Scale: 1″ = 4′. Determine the true length and inclination of the shortest connector.

B. A line going from point C bears N60°E and falls at a −.6 slope. Point E is located 20 feet due east of point C and at an elevation of 10 ft. above C. Find the shortest distance from point E to the line. Show the connector in all views. Scale: 1″ = 10′.

C. Points GHK lie in a vertical plane which has a strike of N30°W. A line from G to H declines at an angle of 60°. Point K is 44 feet vertically below G. Find the shortest distance from K to line GH. Scale: 1″ = 20′.

D. A line starting at point B falls at a 45° angle and bears N60°W. Point A is 9 feet due west at the same elevation as B. Find the shortest connector between the line through B and a horizontal line bearing N30°E through A. Scale: 1″ = 4′.

E. A line originating at point R bears N45°E and falls at a 30° angle. From point S a line bears due west and also falls at 30° angle. Point S is at the same elevation as R and is 125 feet due east and 20 feet in front of R. Find the shortest connector between the two lines. Scale: 1″ = 50′.

F. In each case, draw the H and F projections of the two non-parallel, non-intersecting lines that will satisfy the given conditions:

1. The shortest connector equals the vertical connector.
2. The shortest connector equals the shortest horizontal connector.
3. The shortest connector equals the shortest frontal connector.
4. The shortest connector equals the shortest profile connector.
5. There is no possible vertical connector.
6. There is no possible horizontal connector.

G. The shortest connector between two non-parallel, non-intersecting lines is a horizontal line 0.75 inch long with a bearing S30°W. Find the shortest 50% grade connector between the two lines using a minimum number of views. Can these two lines have a vertical connector?

H. Two mining shafts are located as follows:
From point Q a new shaft bears N30°E and declines at 30°. Point R is 180′ east and 250′ north of Q and at the same elevation as Q. From point R an old shaft bears S75°W and declines at 20%. Scale: 1″ = 100 feet.

1. Determine true length, percent grade and bearing of the shortest connecting shaft.
2. Find true length and bearing of the shortest horizontal connecting shaft.

I. A horizontal pipe SM runs due west. A second horizontal pipe CK runs N30°E but is 3 feet lower than SM. Connect the two pipes with a third pipe using 45° elbows at the connections. Determine the length, bearing and inclination of the connector.

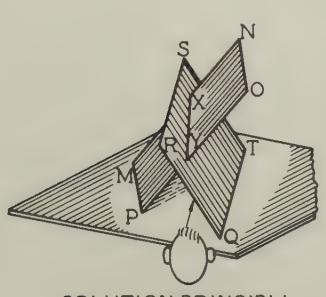
SPACE GEOMETRY—LINES AND PLANES

USES

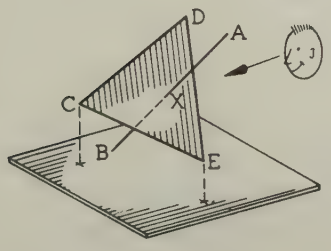
- An almost infinite variety of practical applications of the geometry of lines and planes is found in all types of engineering work. "Angle between a line and a plane" problems are common. Applications involving such relationships as those found between table legs and table tops, heating ducts intersecting furnace plenums and brackets brazed to baffle plates, are examples. Solutions for "dihedral angles" found on such items as hopper faces, aircraft wings and bridge abutments—utilize the basic principles presented in this unit of work.

OBJECTIVES

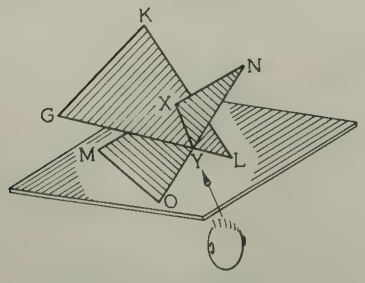
- Same as for points and lines.
- To solve problems involving angles between a line and plane, piercing point of line and plane, line of intersection between planes and dihedral angle between planes.
- To visualize in three dimensions that which is solved on two dimensional paper.



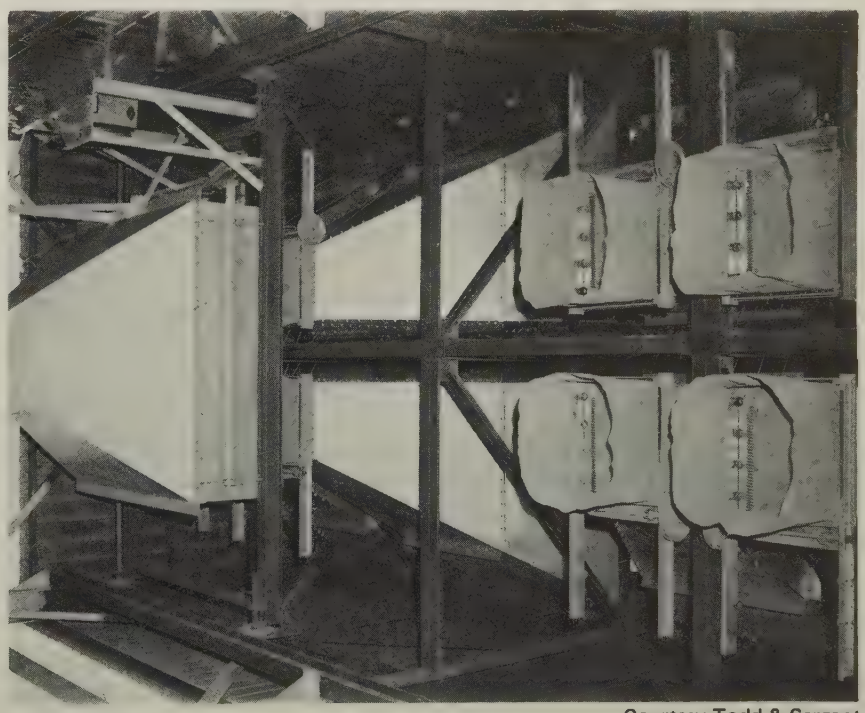
SOLUTION PRINCIPLE



SOLUTION PRINCIPLE



SOLUTION PRINCIPLE



Courtesy Todd & Sargent

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GEOMETRY OF LINES AND PLANES

A. Angle Between Line and Plane (1)

Procedure: Position a pencil so that it extends through the opening in a plastic triangle and makes an angle of about 30° with the plane of the triangle. Keeping this 30° angle relationship constant, position the triangle so you have the edge view of it at all times. Slowly rotate the model and observe the changing projection of the angle. Now complete the following:

1. The true size of the angle between a given line and plane can be viewed only when the plane projects as _____ and the line projects in _____ _____.

2. As the model rotates the *projected* size of the angle changes from its _____ _____ to a maximum of _____ degrees.

B. Angle Between Line and Plane (2)

Basis: Projection of a Point or Line onto an Oblique Plane. In projecting a point or line onto a given oblique plane the essentials of orthographic projection used in projection to the standard planes—horizontal, front, profile, back, etc.—are used. Review these principles quickly in your mind.

Hold a plastic triangle in an oblique position. Place a pencil so that it intersects the triangle at about 60° angle. Imagine a projector from the end of the pencil farthest from the plane that is perpendicular to the plane. Where this perpendicular projector pierces the plane is THE PROJECTION of the end point of the line. Now imagine a line drawn from this PROJECTED POINT to the previously established piercing point. This line is known as THE PROJECTION of the given line on the given oblique plane. Study this model thoughtfully and answer the following:

1. The given line and its _____ intersect at the piercing point of the given line and plane.

2. The given line and its PROJECTION form a _____ that is _____ to the given plane.

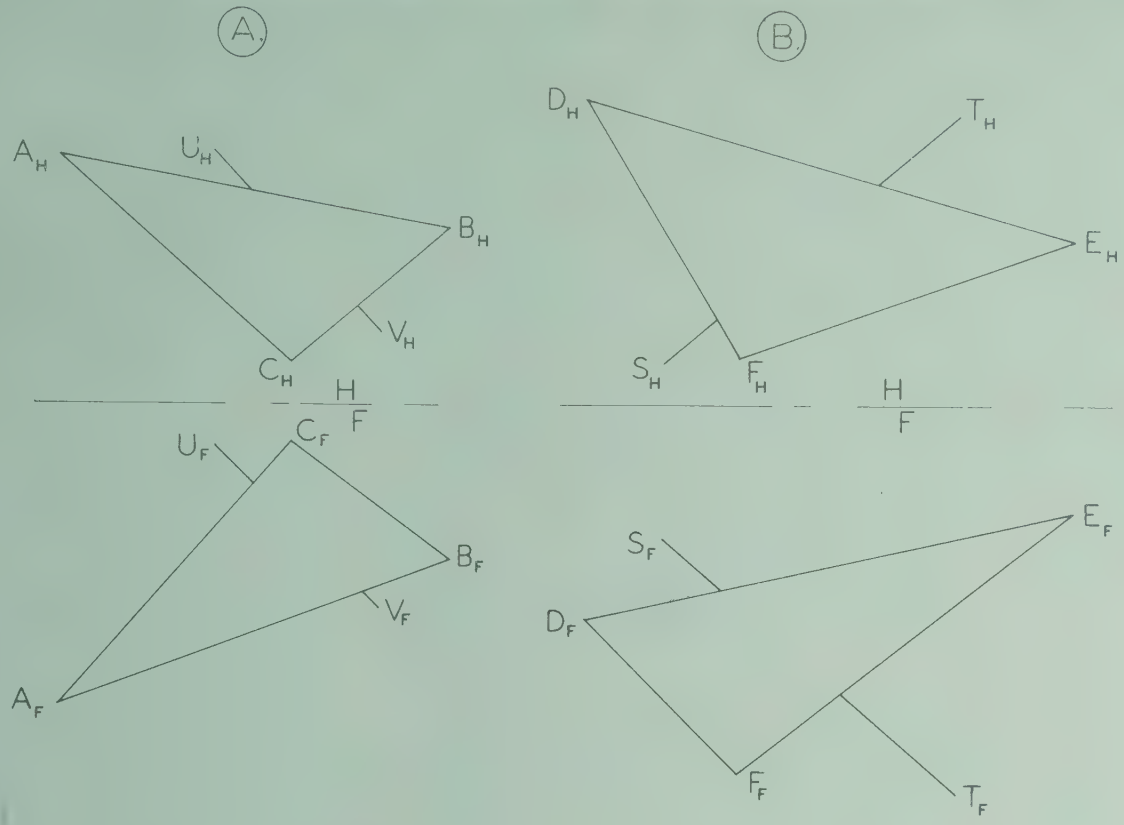
Rotate the model to a position showing the T.S. of the plane containing the given line and its projection. Note that this view is identical to that found in "A" preceding, i.e. line in T.L.—plane as edge. One can, however, ignore the given plane as an edge and concentrate on the given line and its PROJECTION only. In other words, the angle between a line and a plane is coincident with the angle between the line and its PROJECTION on that plane.

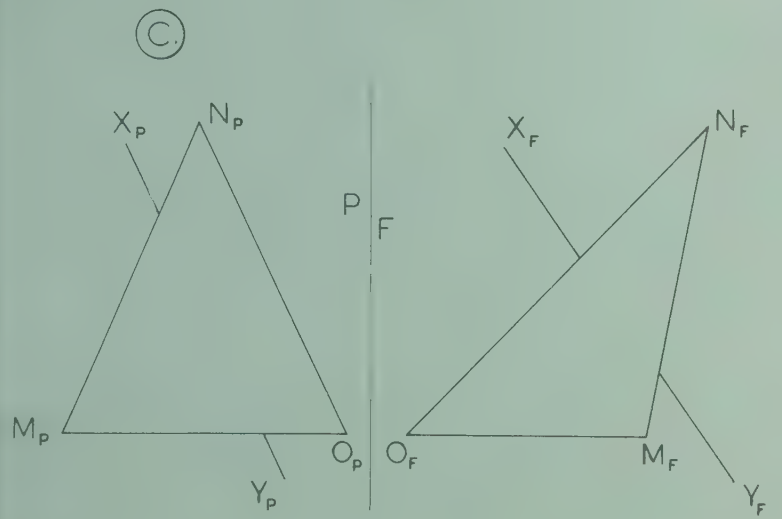
C. An orthographic view showing the _____ _____ of a plane containing a given line and its _____ on a given plane coincides with the view showing the given plane as an _____ and the given line in _____. Thus either approach results in a view showing the _____ _____ of the angle between the _____ _____ and the _____ _____.

A. 1. an edge, true length
2. true size, 90°

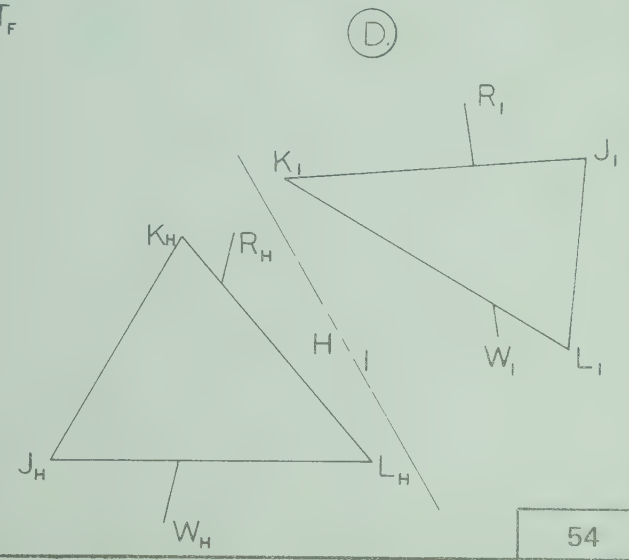
B. 1. projection
2. plane, perpendicular

C. True size, projection, edge, true length, true size, given line, given plane





Find point P where the line in each problem pierces the given plane. Use the edge view method in problems A and B, and the auxiliary plane method in problems C & D. Treat the planes as opaque and show proper visibility of each line.



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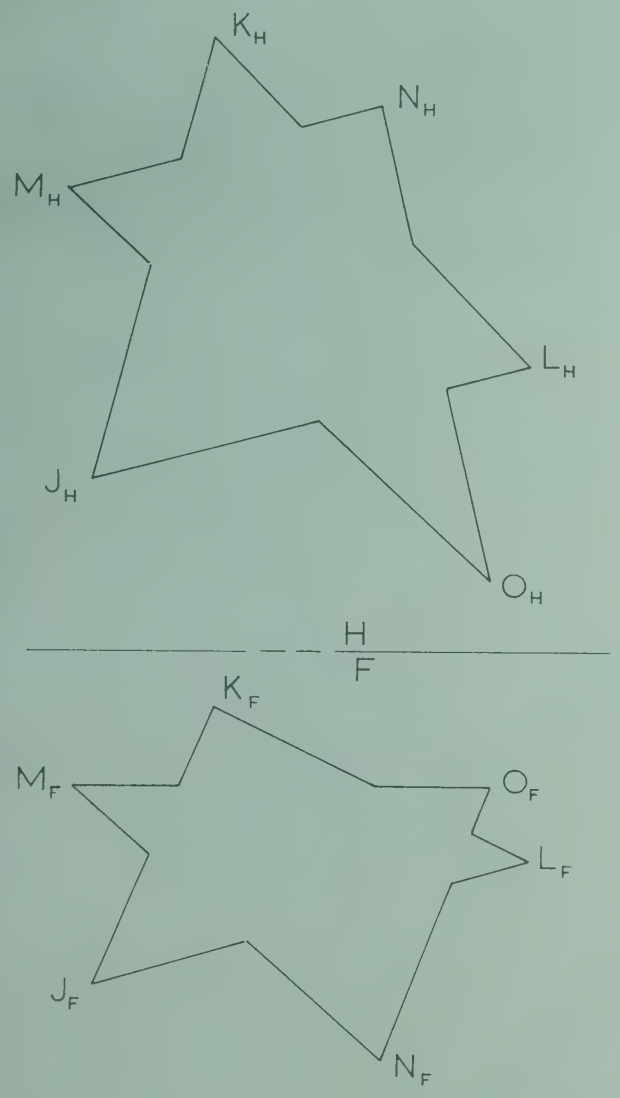
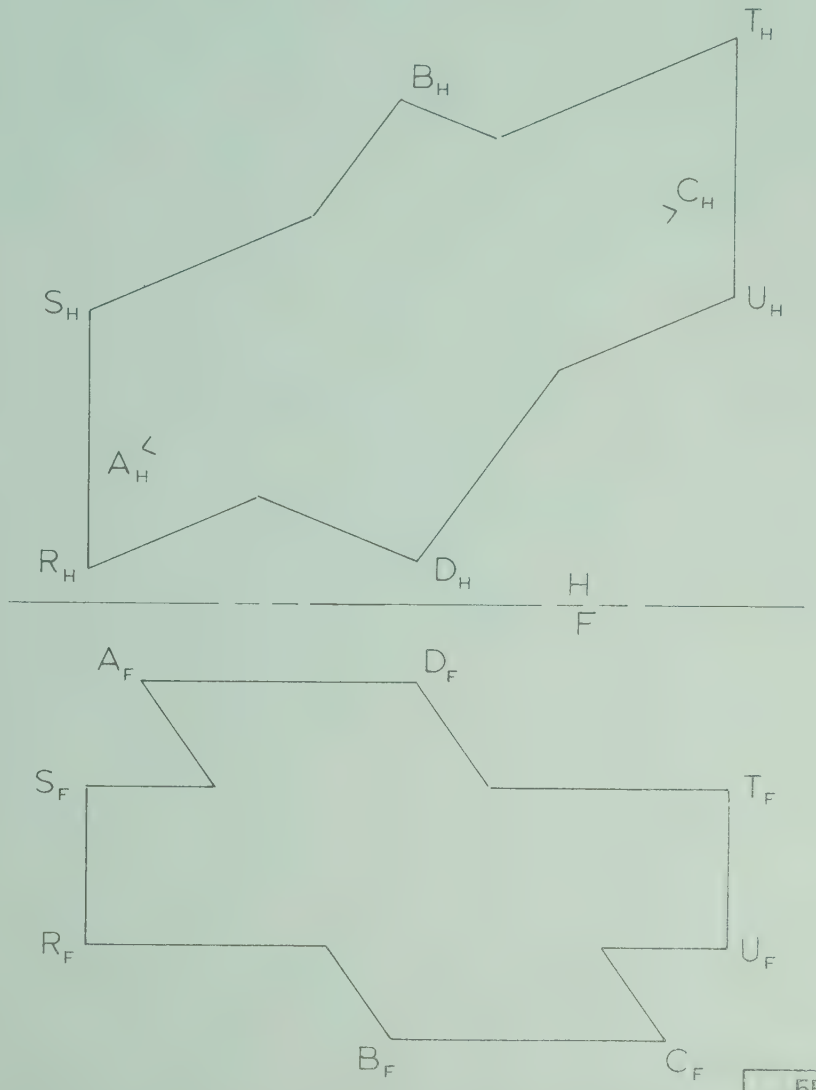
A. Find the line of intersection of planes JKL and MNO using the edge view method. Show proper visibility in all views.



B. Determine the line of intersection of the two given planes using the cutting plane method. Show proper visibility.



COURSE: DATE: DR. BY: DR. NO.
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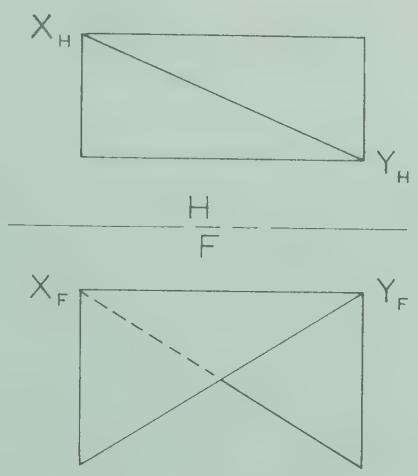
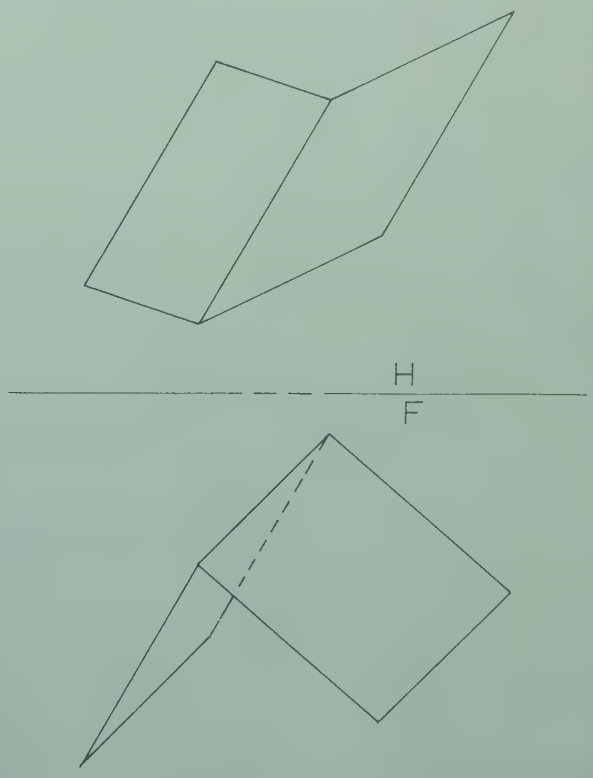
Find the dihedral angles between the planes.

A.



B.



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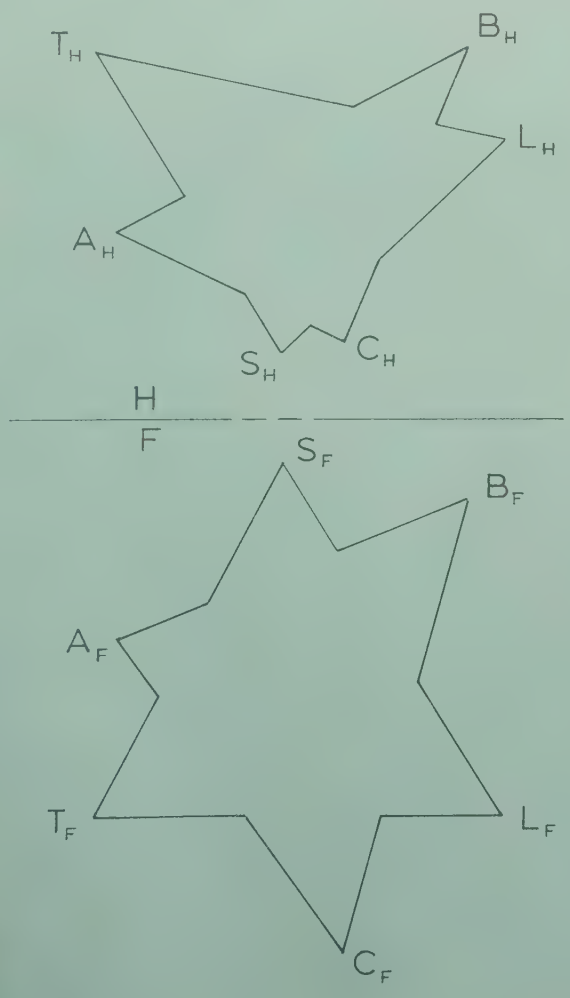
Horizontal and front views of two planes are given.

A. Find the line of intersection between the planes.
B. Find the dihedral angle between the planes.



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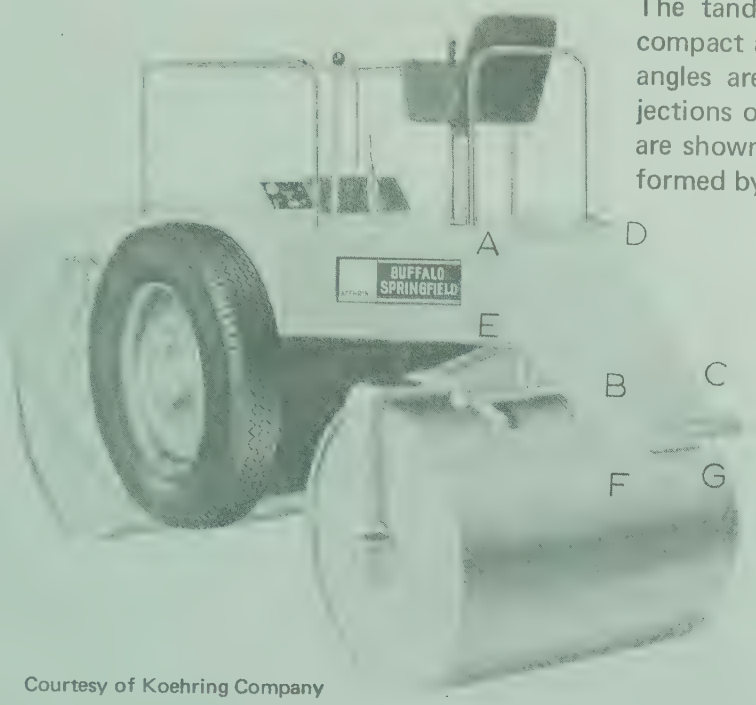
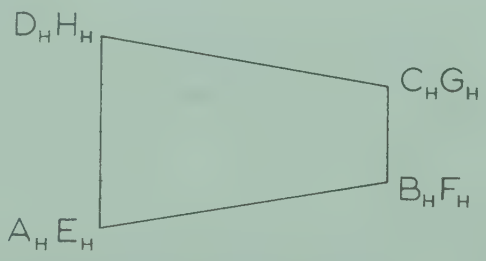
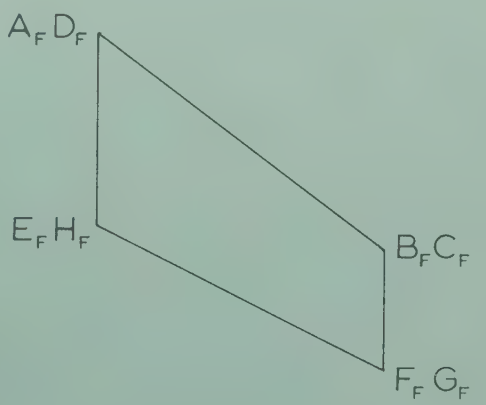
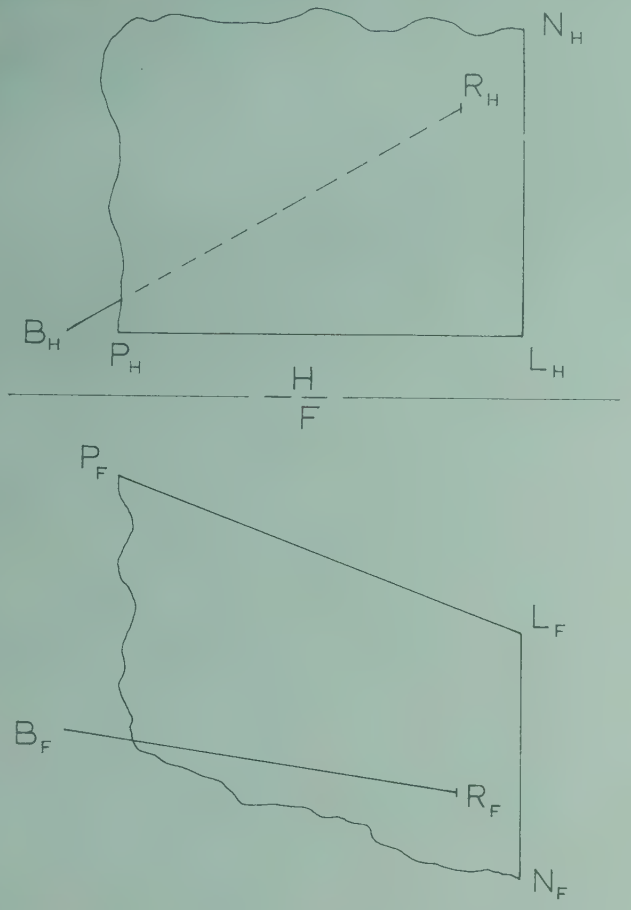
The tandem roller pictured here is used to compact asphalt road surfaces. Many dihedral angles are involved in the design. Two projections of the bracket for the draw bar hitch are shown below. What are the dihedral angles formed by these planes?



Courtesy of Koehring Company

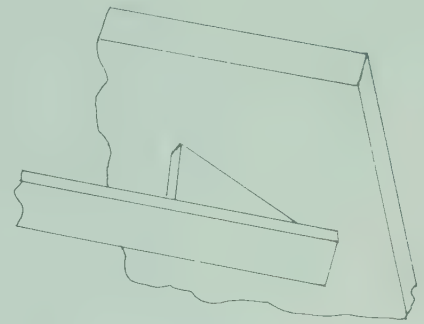






A. State the solution principle for finding the true size of the angle between a line and a plane.

B. A brace located along line BR is to be welded at an angle to the plane located by points PLN. Find the true size of the angle between the line and the plane.



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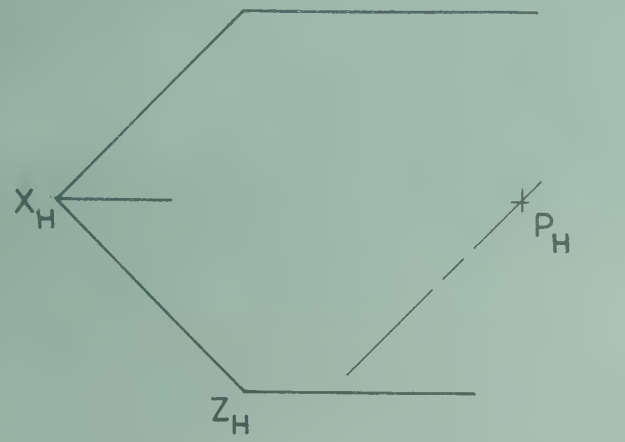

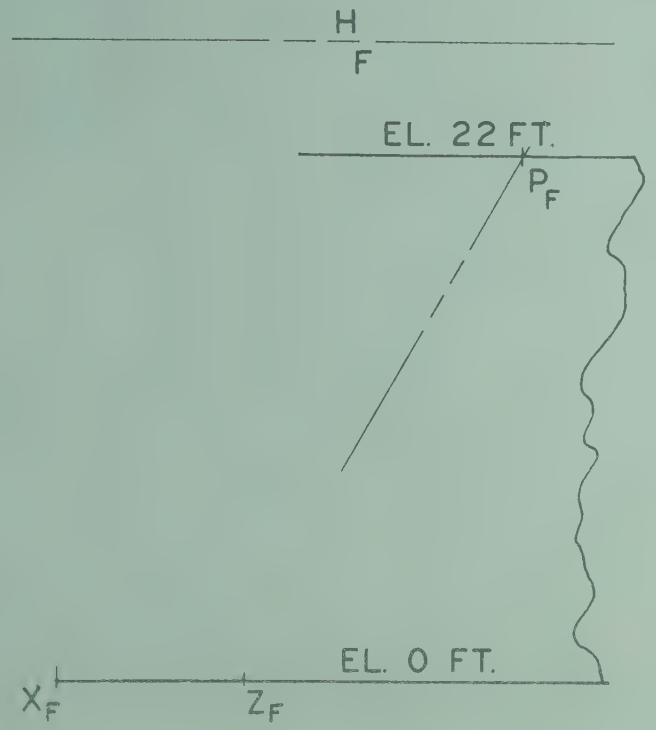

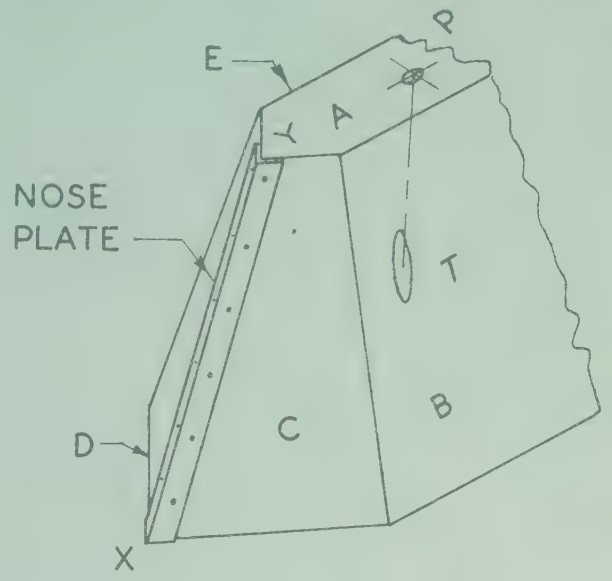

BRIDGE ABUTMENT

To construct the bridge abutment and fabricate the nose plate, the following information is desired:

a. A complete plan and elevation view.
b. Angle between faces A and B.
c. Angle between faces B and C.
d. Angle between faces C and D.
e. Angle between nose edge and face A.
f. Location of point T where the center line of a drain pipe through P will intersect the face of the abutment.

Note: Batter of all faces is 4:1.

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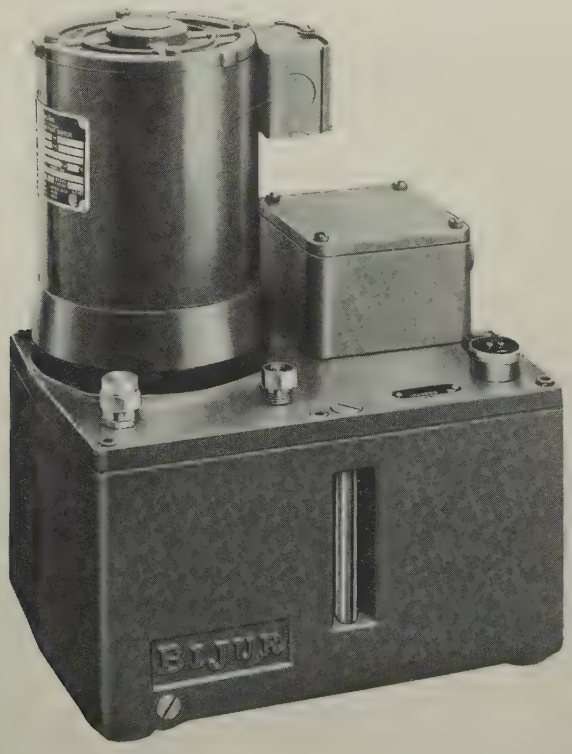
ORTHOGRAPHIC PROJECTION—SOLIDS

USES

- In general—same as for points and lines. Most industrial products are three-dimensional in nature. Application of solids in orthographic projection as related to industry is a natural and logical counterpart of points and lines.

OBJECTIVES

- General—Same as for points, lines and planes. Increased emphasis on developing visualization and concepts concerned with opaqueness and visibility.
- Specific
  - Be able to interpret pictorial views of objects and produce correct orthographic views of the object and vice-versa.
  - Be able to add missing lines required for correct interpretation of partially completed problems.
  - Be able to delineate or choose alternate correct solutions to problems where one or more correct orthographic views have been given and more than one solution is possible.
  - Be able to correctly interpret "solids" involved in industrial drawings.
  - Be able to draw or sketch orthographic views of solids from written descriptions.



Courtesy of Bijur Lubricating Corporation

DR. NO.:_ GRADE:

ORTHOGRAPHIC PROJECTION–SOLIDS

As an engineering student, the development of the ability to recall fundamental principles learned in the past and to relate, and to properly apply them in current problems is of utmost importance. Demonstrate this ability as you complete the following exercises related to orthographic projection.

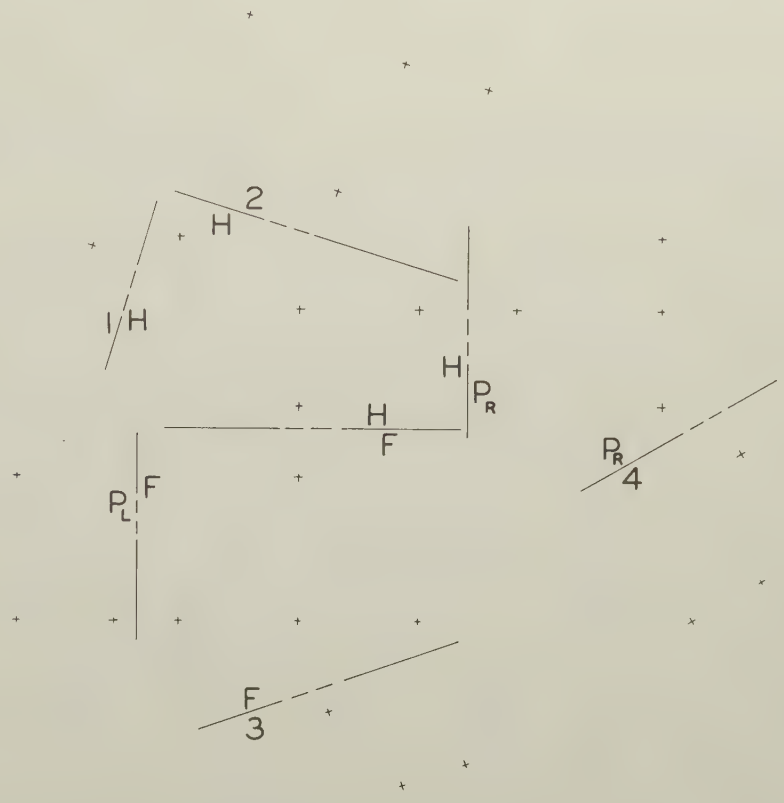
A. Label the following points in all indicated views:
(Scale: 1″ = 1.0″)

A = .25 below H
.875 L of P_R
.625 behind F

B = 1 below H
.875 L of P_R
.125 behind F

C = 1 below H
.25 L of P_R
.625 behind F

D = 1 below H
1.5 L of P_R
1 behind F



B. Complete the following statements:

1. The projections just made are orthographic projections of specific _____ in space.
2. Join the projections of points A and B in all views with straight lines. These are _____ projections of line AB.
3. In the same way, connect the projections of B and C. ABC identifies a _____ surface.
4. In each view, connect *all* projected points with straight lines of correct visibility. The views now represent the orthographic projections of a _____ .
5. The entire figure was achieved by the location of certain key points using the drawing system called _____ _____. The key points were in turn connected by _____ _____ which define _____ surfaces found on the various faces of the _____.

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A. H (1) Principle; (2) ABC, ACD, ABD; (3) None; (4) BCD; (5) BC, CD, DB; (6) Profile
F (1) Principle; (2) ABD, ABC, (3) BCD; (4) None; (5) AC; (6) Horizontal
P (R) (1) Principle Elev.; (2) ABC, ACD; (3) BCD; (4) None; (5) AB; (6) Horizontal
P (L) (1) Principle Elev.; (2) ABD; (3) BCD; (4) None; (5) AB; (6) Frontal
1 (1) Aux. Elev.; (2) ABD; (3) ACD; (4) None; (5) None; (6) Oblique
2 (1) Aux. Elev.; (2) ACD; (3) BCD; (4) None; (5) DC; (6) Oblique
3 (1) Inclined; (2) BCD; (3) None; (4) None; (5) None; (6) Oblique
4 (1) Inclined; (2) ABC, ABD; (3) None; (4) None; (5) None; (6) Horizontal

C. Check with your instructor if any question.

B. front, 1 (one)

D. critical contour

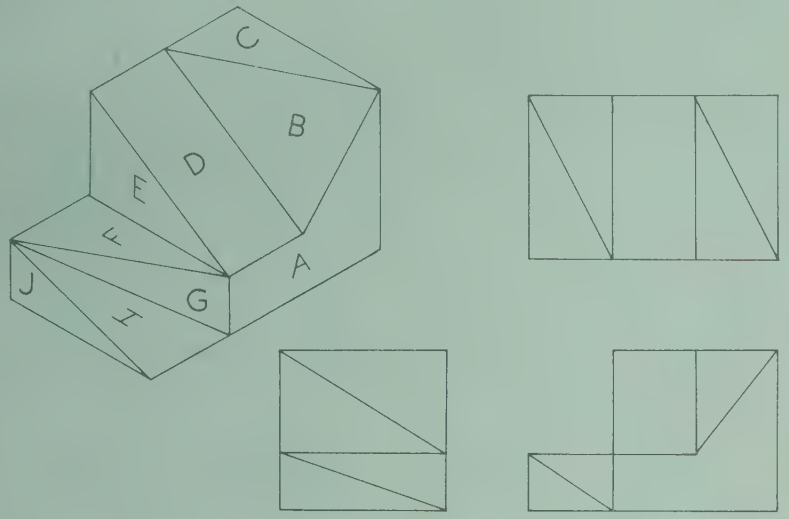
F. detail, visible (viewed or seen)

E. identical

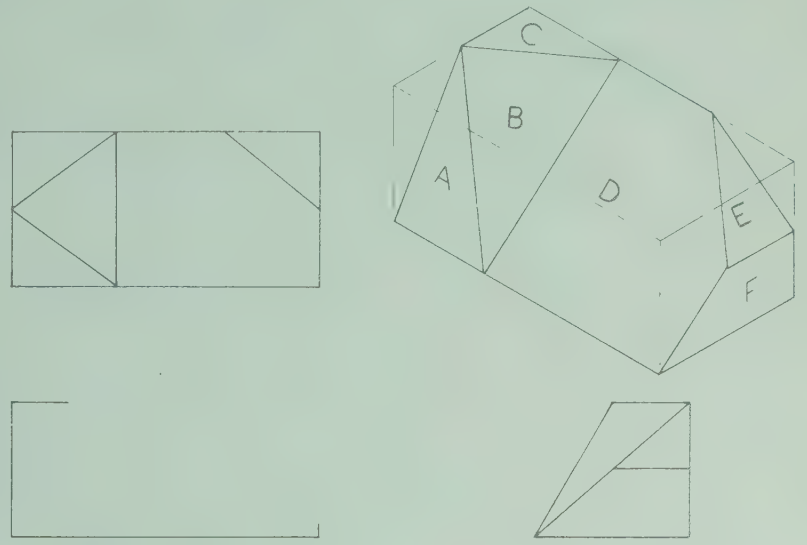
H. object
center

G. intricate (critical), contour

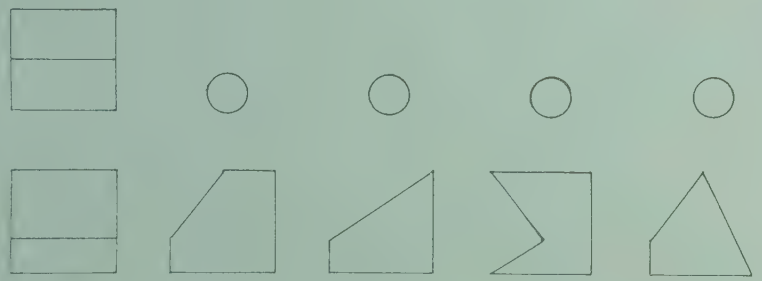
A. Identify the surfaces by placing the correct letter in each closed area in the orthographic views.



B. Complete the missing front view and identify all visible surfaces in each view.



C. Place a T or F in the circles above the right profile views to indicate correctness of each. Make a small pictorial sketch of each correctly drawn object.



D. Sketch four different but correct right profile views. Make a small pictorial sketch of each.

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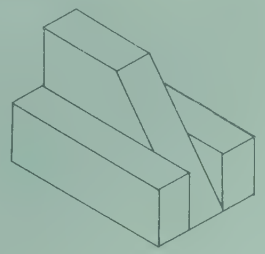
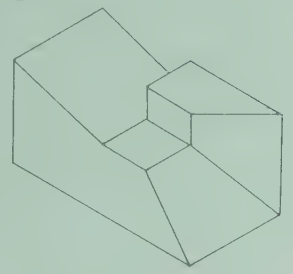
Sketch the necessary orthographic views for complete shape description of the given objects.

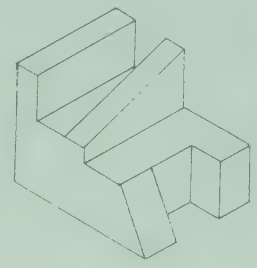
A.



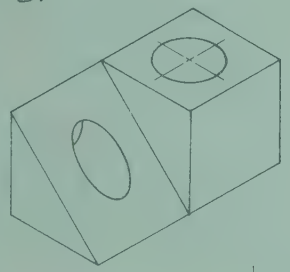
B.



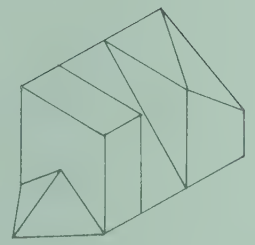
C.



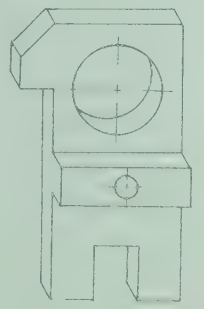
D.



E.



F.



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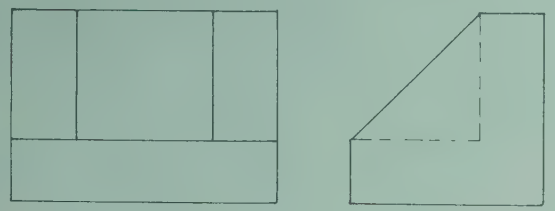
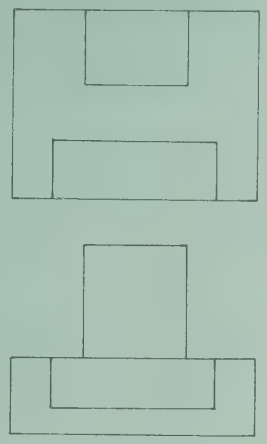
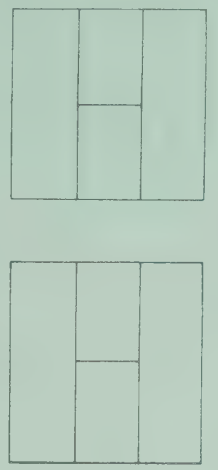
Complete a third view from the given two complete views. Cross out any unnecessary views. Add a small pictorial sketch of each object.



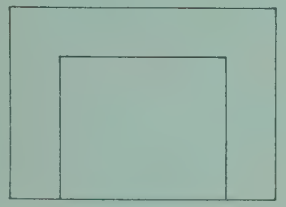
A.

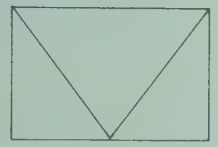


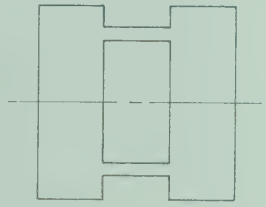
B.

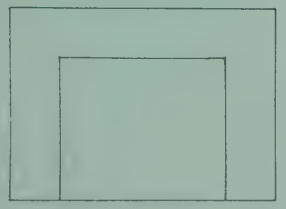


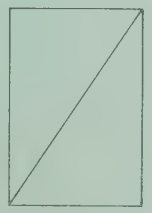
C.

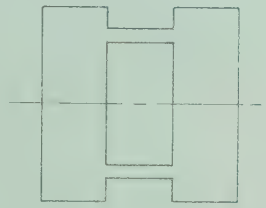












D.

E.

F.

	COURSE: DATE: DR. BY:		DR. NO.
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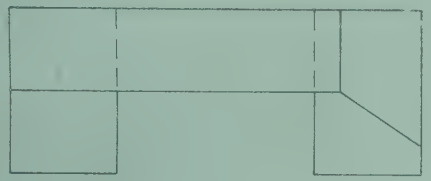
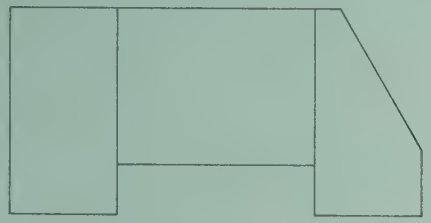
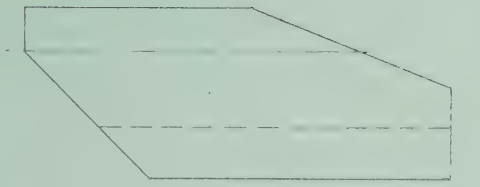
Add a third view to the given two-view drawings. Sketch a pictorial of each.

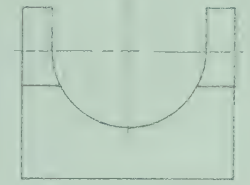
A.



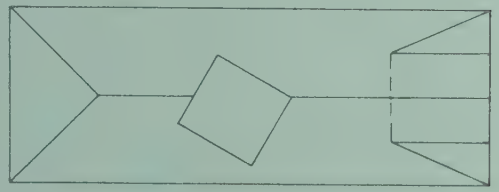


B.

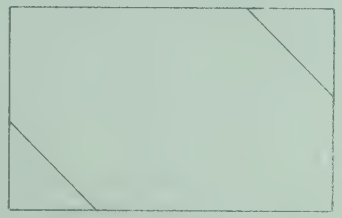


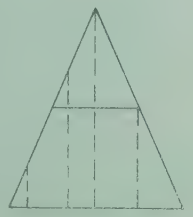


C.



D.





COURSE: DATE: DR. BY:
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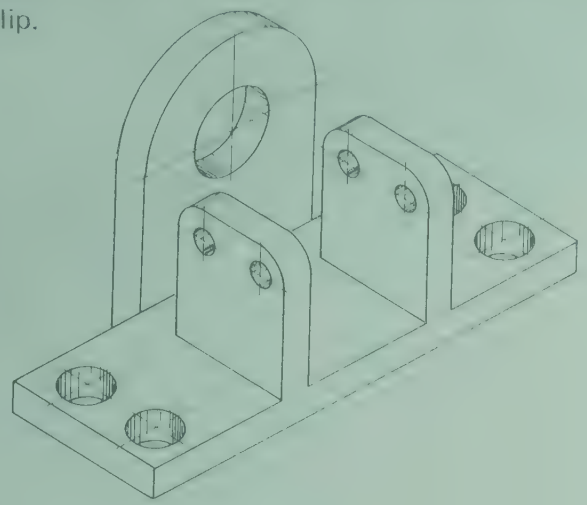
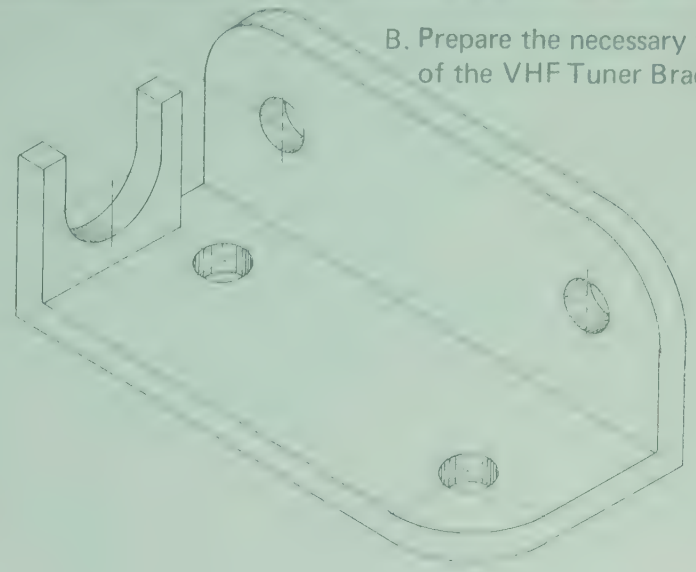
DR. NO.
GRADE

A. Prepare the necessary views of the Pole Assembly clip.

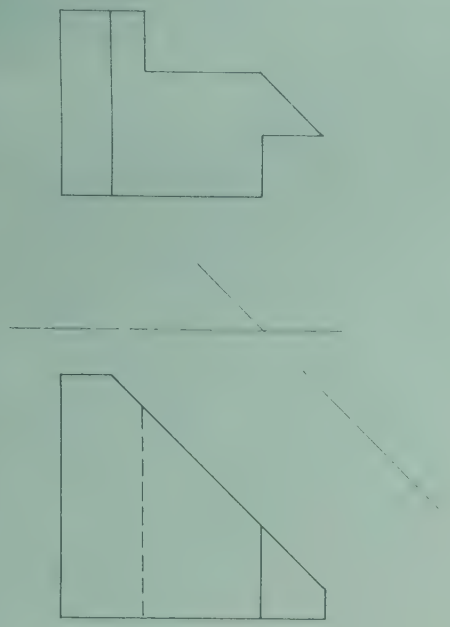


B. Prepare the necessary views of the VHF Tuner Bracket.

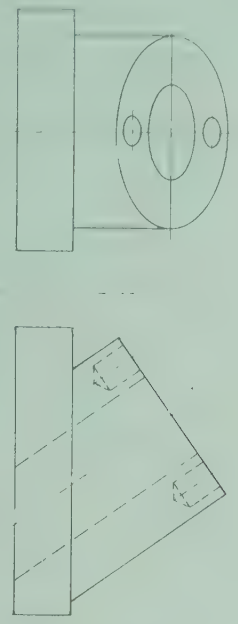


	COURSE : DATE: DR. BY:		DR. No.
	SECTION: TABLE: INSTRUCTOR:		GRADE:

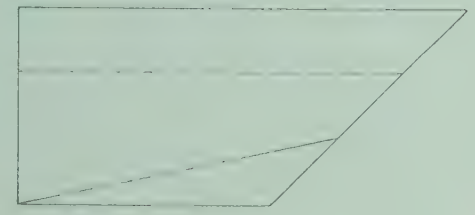
A. Draw the indicated auxiliary projection of the inclined surface.

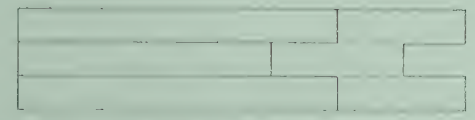


B. Draw a true size view of the inclined face of the Angle Mount.



C. Draw a true size view of the right-hand end of the Slotted Angle Stop.





	COURSE:	DATE:	DR. BY:	D# NO.
	SECTION:	TABLE:	INSTRUCTOR:	GRADE:

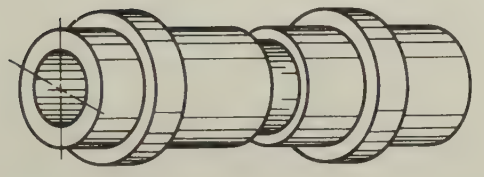
PICTORIAL SYSTEMS

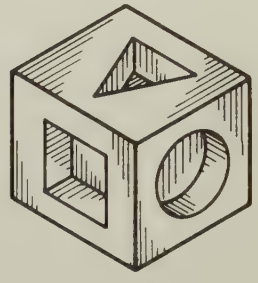
USE

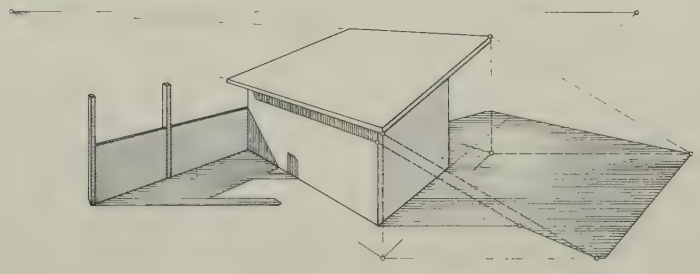
- Used extensively for both sketches and instrument drawings where the three-dimensional or picture effect of the object is important. Used extensively throughout industry in engineering, architecture, advertising and sales. Especially valuable for concept sketches in design work, on assembly lines, and in catalogs, service manuals and advertising brochures.

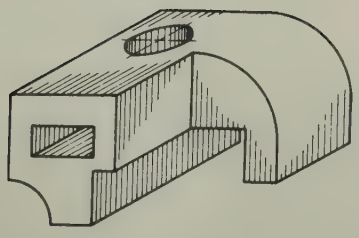
OBJECTIVES

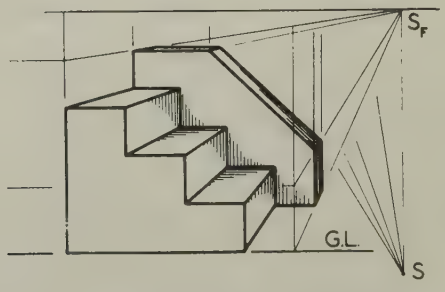
- Be able to distinguish between the various types of pictorial systems and understand the relative advantages or disadvantages of each type.
- Given orthographic views to completely describe a relatively simple object, be able to select an appropriate type of pictorial, choose logical axes positions, and correctly delineate a freehand or instrument pictorial of the object. It should be well proportioned, technically correct in detail and correctly positioned on the paper.











Courtesy Rising, Almfeldt & DeJong

PICTORIAL

A. List the three major categories of pictorial drawing:

_____ _____ _____

B. Define axonometric projection:

C. Illustrate (with small freehand sketches of cubes) the three types of axonometric drawing. Label each:

D. Illustrate the three standard positions of *axes* for isometric drawing (sketch small cubes—darken major axes):

E. Illustrate (sketch small cubes) the three types of *oblique* drawing and *four different* axes positions for same:

F. Illustrate (with an instrument isometric drawing of a block with a large hole through it) the 4-center ellipse construction:

G. Compare (list advantages, disadvantages, when each is appropriate, etc.) oblique drawing with axonometric.

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DR. NO.:

GRADE:

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INSTRUCTOR:

DATE:

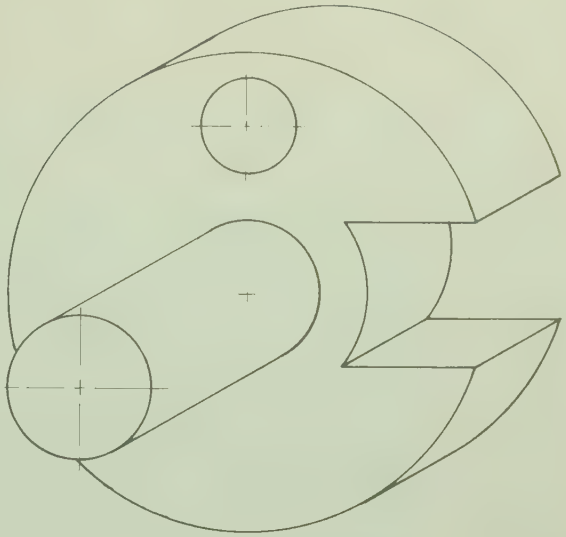
TABLE:

COURSE:

SECTION:

A. Define a cabinet drawing:

B. Make a double size *cabinet* drawing of the object shown in cavalier.



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DR. NO.

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INSTRUCTOR:

COURSE:

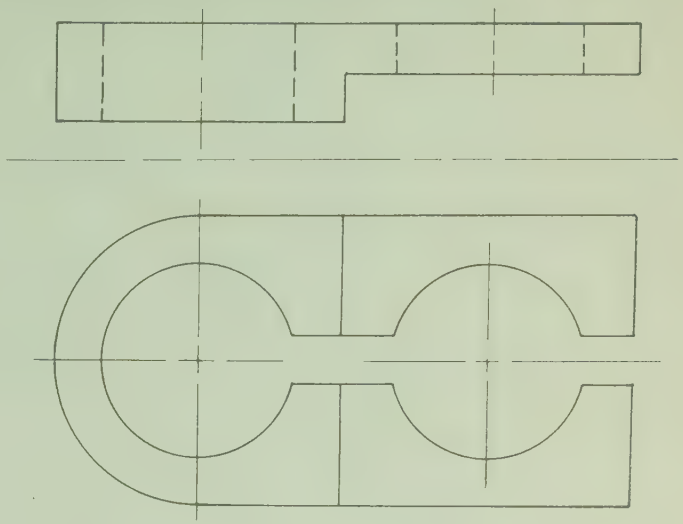
SECTION:

DATE:

TABLE:

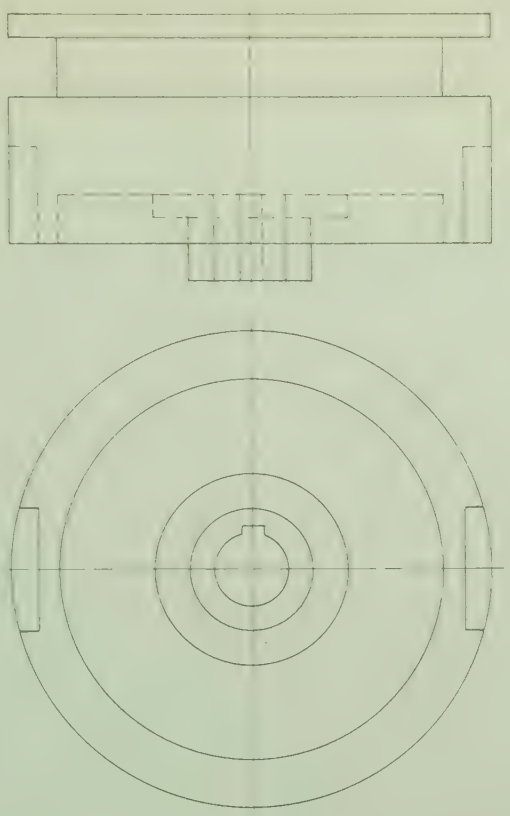
A. Sketch an appropriate oblique pictorial of the object shown.

B. Draw (instruments) a *double* size *cavalier* oblique pictorial of the object shown.



COURSE:	DATE:	DR. BY:	DR. NO.
SECTION:	TABLE:	INSTRUCTOR:	GRADE:

Make instrument drawing (oblique) of the power brake assembly.



Courtesy of Simplatrol Products Corporation

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DR. NO.

GRADE:

DR. BY:

INSTRUCTOR:

COURSE:

DATE:

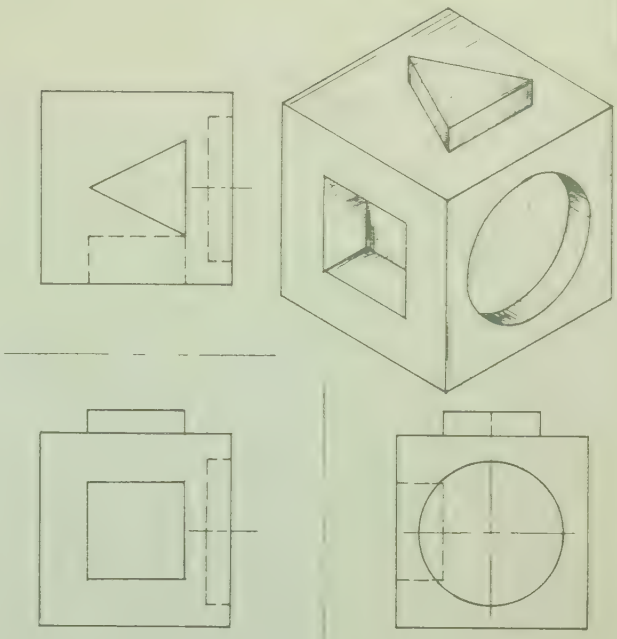
SECTION:

TABLE:

A. Define Isometric drawing:

B. With instruments make an isometric drawing of the object shown (Scale 3:1). Use 4-center construction on the ellipse. Show construction lines (lightly).

C. Make an isometric sketch of the object shown (approximately 3:1). Show construction lines (lightly).



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DR. NO.

GRADE:

DR. BY:

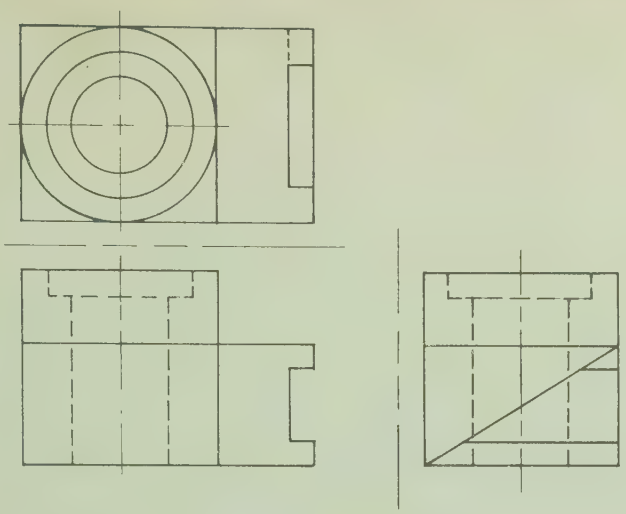
INSTRUCTOR:

DATE:

TABLE:

COURSE:

SECTION:



A. Make an appropriate size (approximate 3:1 scale) isometric sketch of the object shown.

B. Make a 3:1 scale isometric drawing of the object shown.

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DR. NO.:

GRADE:

DR. BY:

INSTRUCTOR:

DATE:

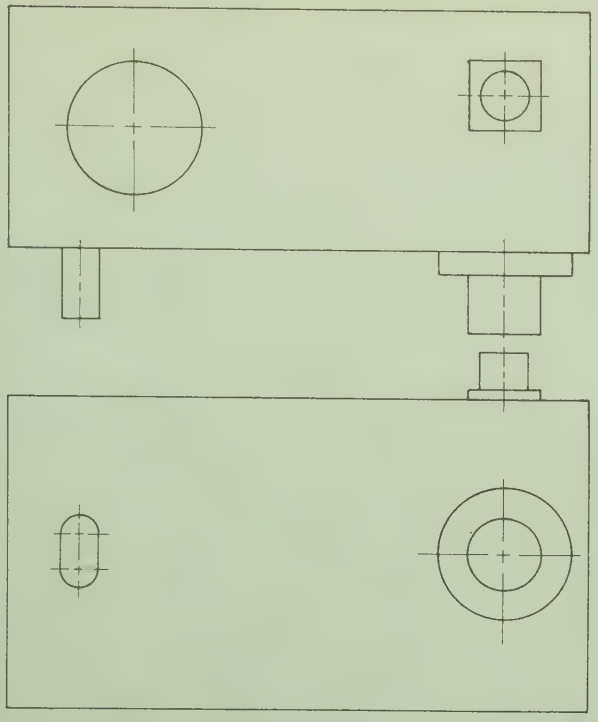
TABLE:

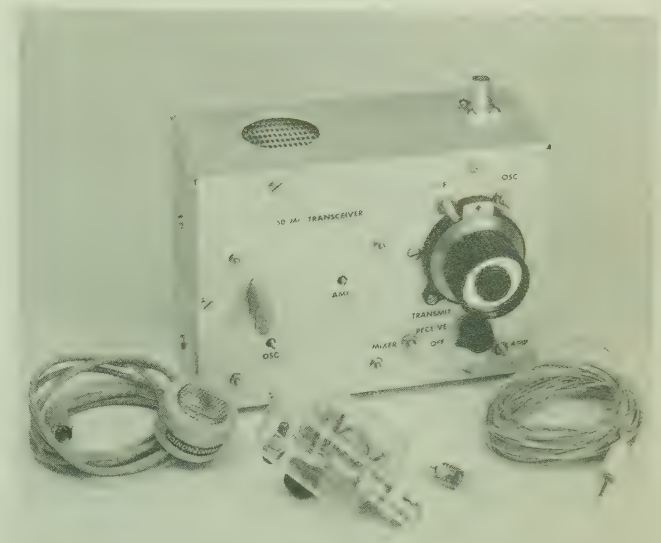
COURSE:

SECTION:

A. Make an isometric drawing (instruments) of the transistor station case as simplified in the given orthographic views.

B. Make an isometric sketch of the transistor station case as simplified in orthographic.





Courtesy of the American Radio Relay League, Inc.

DR. NO.:_ GRADE:_

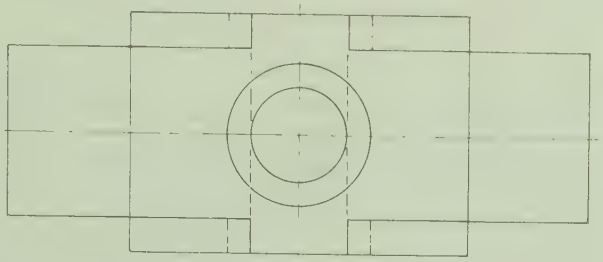
DR. BY:_ INSTRUCTOR:_

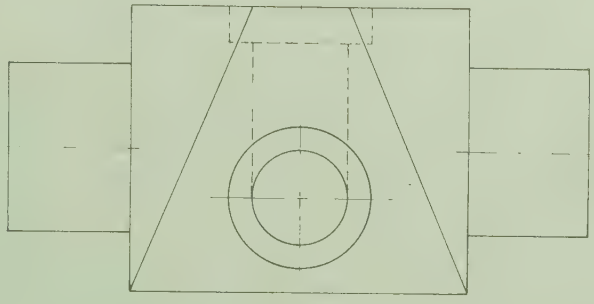
DATE:_ TABLE:_

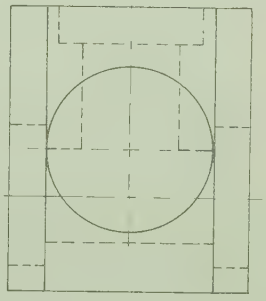
COURSE:_ SECTION:_

A. Make an isometric drawing (instruments) of the solenoid valve housing shown.

B. Make an isometric sketch of the solenoid valve housing shown.







Courtesy of Fluid Power System

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DR. NO.:

GRADE:

DR. BY:

INSTRUCTOR:

DATE:

TABLE:

COURSE:

SECTION:

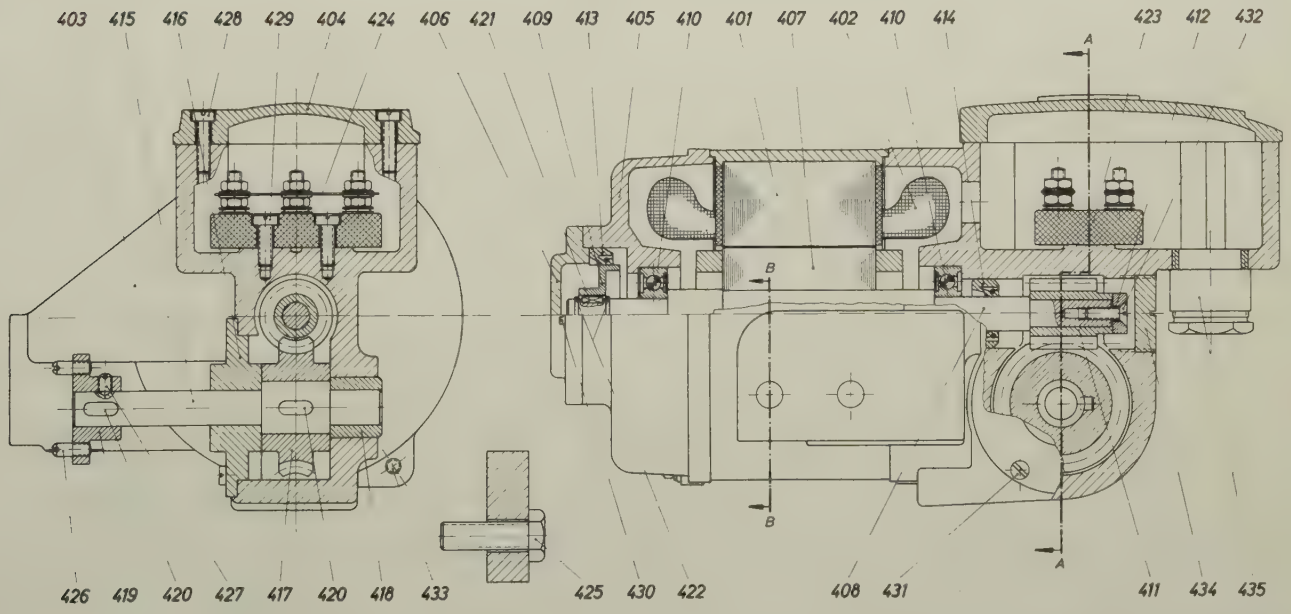
SECTIONS AND CONVENTIONS

USE

- For clarification of complex internal detail of mechanisms, structures or other phenomena where such information is critical. Used frequently in conjunction with orthographic multiview industrial drawings.

OBJECTIVES

- Learn to identify by name or appearance the various section views and apply accepted standards for use of the cutting plane and crosshatching.
- Become familiar with the term conventional practice as it applies to orthographic projection and apply the more common practices used in both sections and standard projections.
- Develop judgment in selecting the appropriate section or conventional practice to apply in a given condition.



Courtesy of Dreisilker Electric Motors, Inc.

ANSWERS–80

A. 1. cutting plane
normal, sectional

2. cutting plane
cutting plane
direction

3. assembly, different

4. standard, clarity
violates

5. not be

6. is not, conventional, is

7. Look up in text and list them as given.

B. 1. b

2. a

3. d

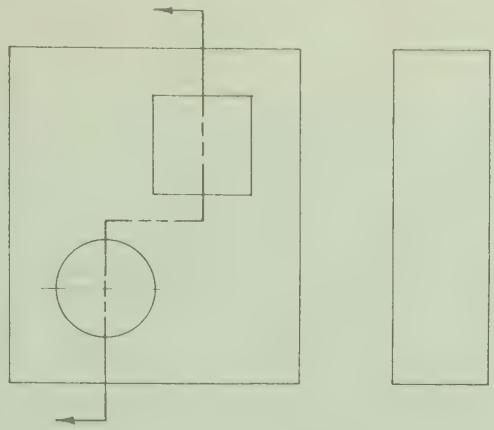
4. f

5. e

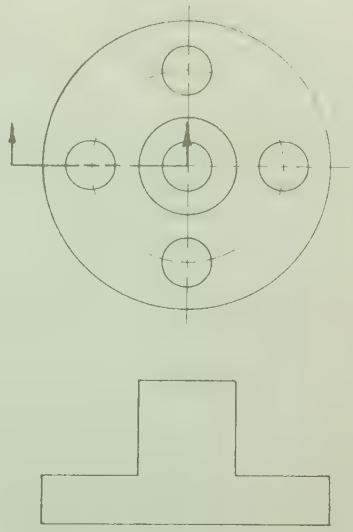
6. c

A. In the space indicated complete a section view of each object as indicated by the cutting plane. Give the type of section for each.

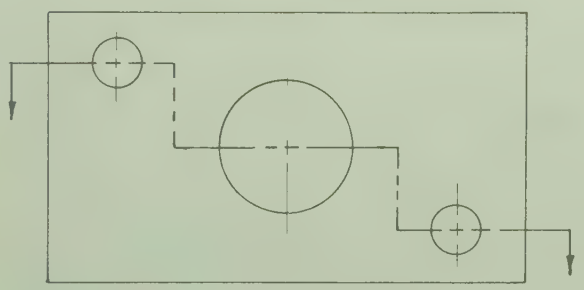
1. Type _____



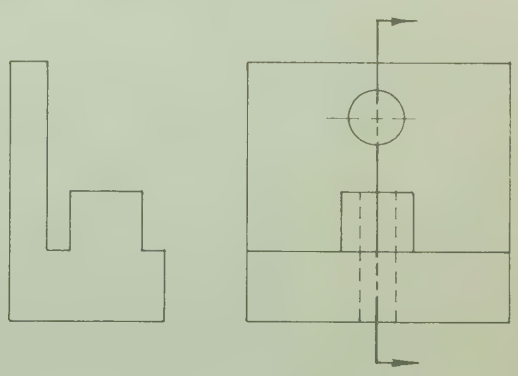
2. Type _____



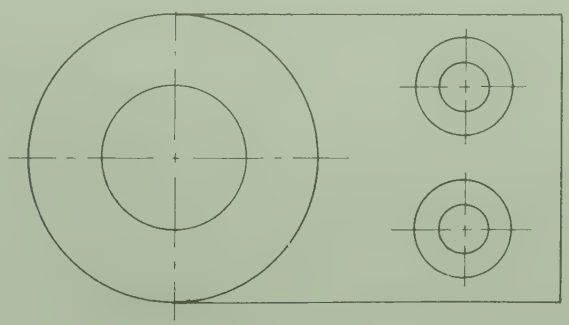
3. Type _____

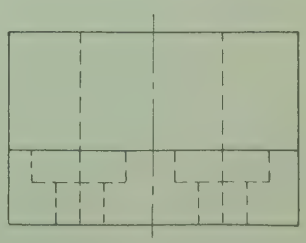


4. Type _____



B. Project from the given horizontal and profile views to complete a view in the normal front view position. Make this front view a section view. Show the cutting plane used.





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DR. NO.

GRADE:

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INSTRUCTOR:

DATE:

TABLE:

COURSE:

SECTION:

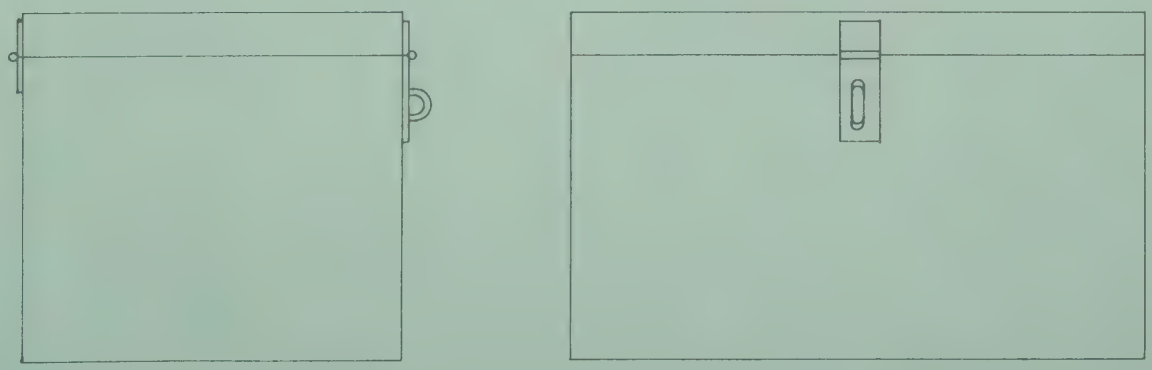
SECTIONS AND CONVENTIONAL PRACTICES

A. The view shown is a length of 1 1/2 × 1 1/2 × 3/16 structural equal angle (see structural steel shapes in text). Complete a revolved section.

B. 1. Use phantom lines to show the box lid in an alternate position.

2. Use a broken out section to clarify inner contours.

3. Use a removed section (double size) to show details of the latch.



DR. NO.

GRADE:

DR. BY:

INSTRUCTOR:

DATE:

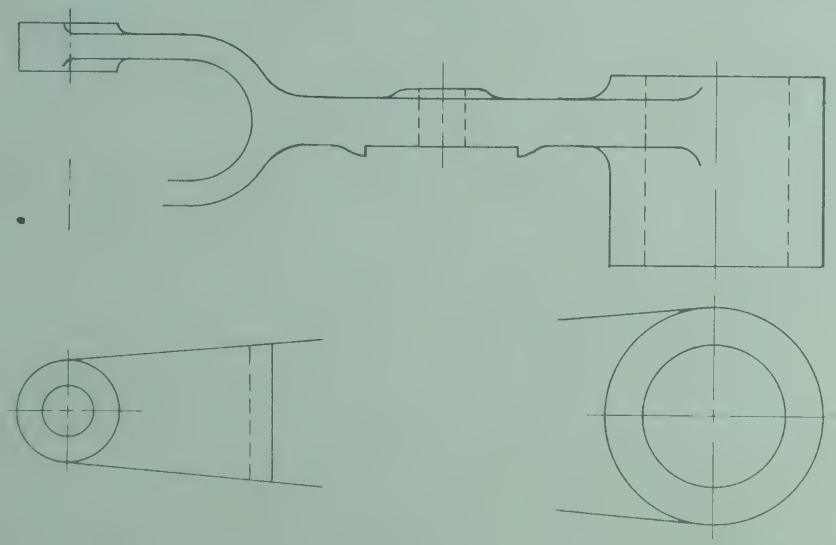
TABLE:

COURSE:

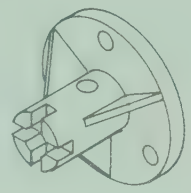
SECTION:

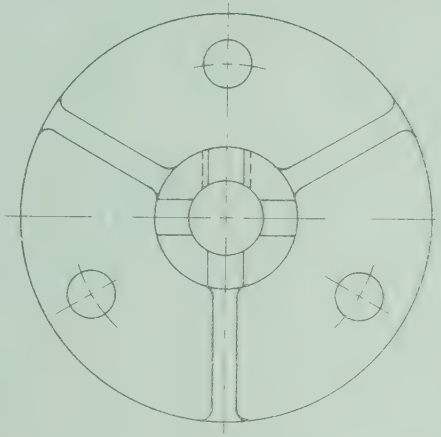
A. Complete the views of the Tractor Yoke, illustrating revolved and broken out sectioning.

Courtesy of Koehring Company



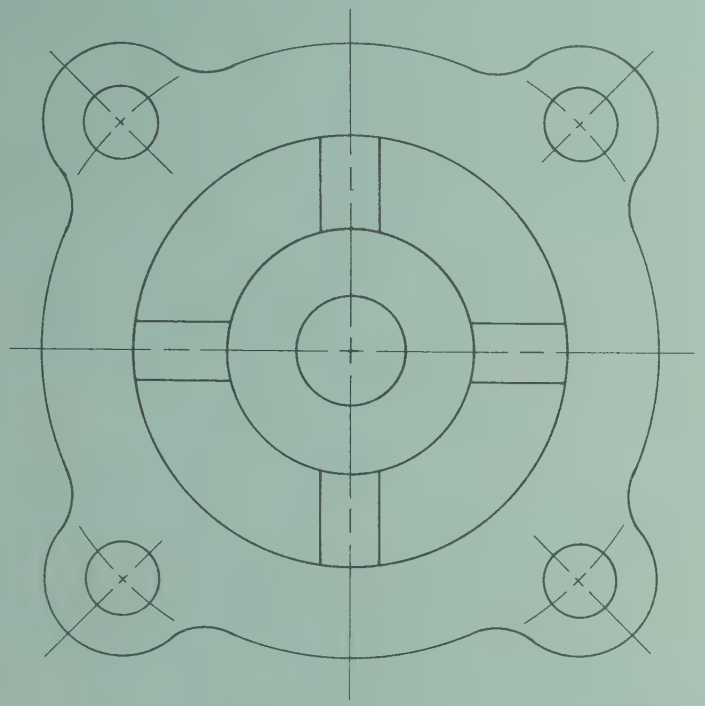
B. Using conventional practices where applicable project a section view from the given view.





COURSE: SECTION: DATE: TABLE: DR. BY: INSTRUCTOR: DR. NO. GRADE:

Below is a single view of an object similar to that in the picture. Make a section view.
Use conventional practices including contours being revolved to improve clarity.



Courtesy of Cerro Copper & Brass Company

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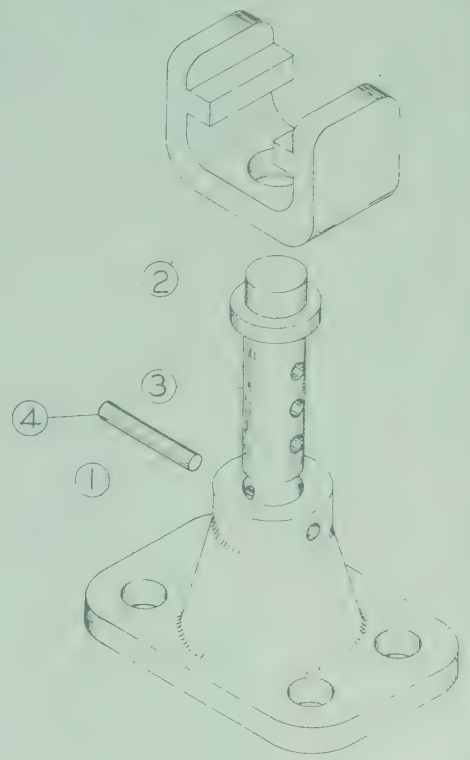
Make a two view Assembly Drawing of the Adjustable Guide. Include an offset section. Double the dimensions taken from the exploded pictorial.



ADJUSTABLE GUIDE

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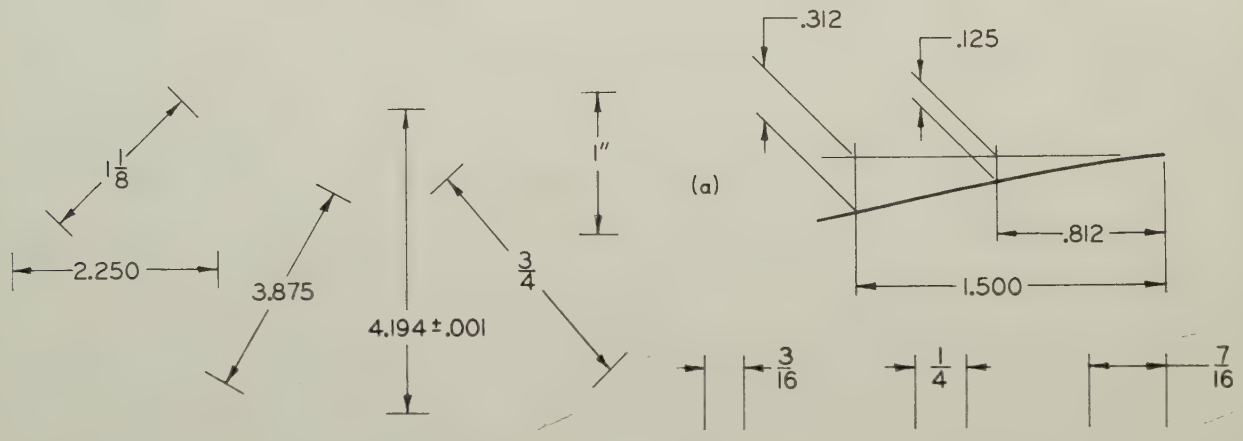
BASIC DIMENSIONING

USE

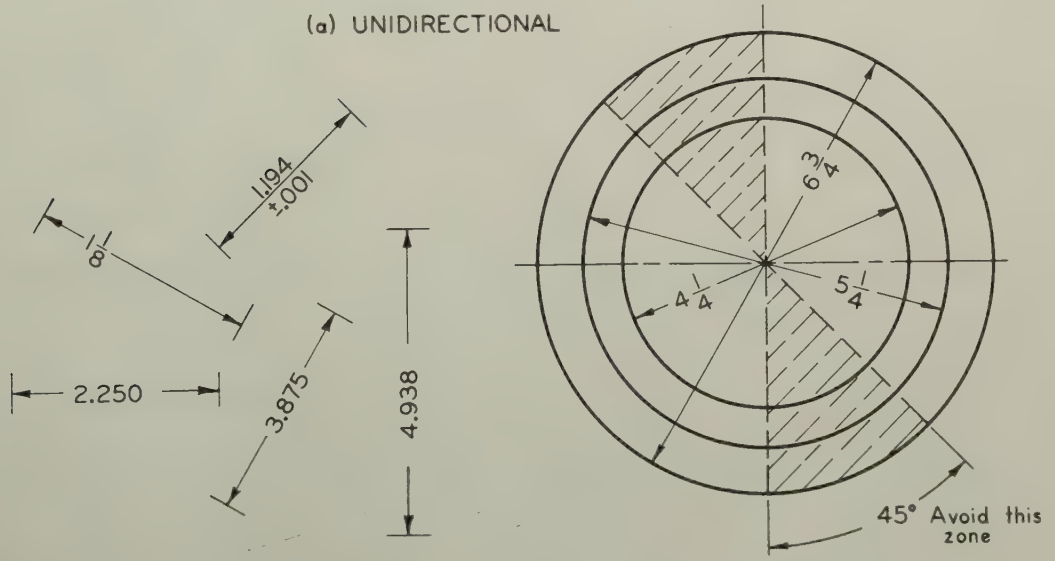
- To provide size and location specifications for the fabrication assembly and utilization of the products of industry. Dimensions are the truly critical culmination of complete shape description. They are generally used in conjunction with orthographic drawings.

OBJECTIVES

- Establish a pattern of logical approach in the analysis of an object to be dimensioned.
- Dimension for the benefit of the people using the drawing—not in a haphazard impulsive manner for your own convenience.
- Understand completely the fundamental rules of dimensioning. Be able to consistently apply these rules correctly when dimensioning orthographic views of relatively simple objects.



(a) UNIDIRECTIONAL



(b) ALIGNED

(c)

DIMENSIONING

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A. On a separate sheet, from memory, list as many of the "good dimensioning practices" as you can. From your text add those you may have missed.

B. Complete the following by supplying missing words.

1. The basic approach to dimensioning includes breaking the object down into its _____ shapes and applying _____ and _____ dimensions to each shape or component feature.
2. Dimensions are placed on a drawing to facilitate _____ of the part, not for the convenience of the _____.
3. Four important criteria in dimensioning are:
   a. That dimension values are correct– _____.
   b. That each dimension is placed in its most appropriate position– _____.
   c. That there are no omissions of specifications– _____.
   d. That lettering, numerals, and dimension lines are neat, uniform in size, and very distinct– _____.
4. The preferred basis for decimal dimensioning is a _____ place decimal.
5. Direction of reading dimensions on a drawing is either _____ or _____.
6. Avoid dimensions within the _____ of a view whenever practicable.
7. The _____ and _____ of a positive cylinder should be given in the _____ view of the cylinder.
8. The _____ dimension of a negative cylinder (hole) is generally given in preference to the _____. The _____ and _____ of a hole is usually given by a _____ note referred to the _____ view.
9. Overall dimensions (should) (should not) be used with parts having rounded ends.
10. The _____ rule states that "Dimensions should be related to the view that shows the most _____ shape."
11. On another sheet, with two-view orthographic sketches illustrate proper dimensioning of a counterbored and a countersunk hole.
12. On another sheet, list recommended general steps of procedure for any dimensioning problem.

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1. Geometrical
   size, location

3. ACCURACY, CLEARNESS, COMPLETENESS, READABILITY

2. production, draftsman

5. Unidirectional, aligned

4. two

7. diameter, length, rectangular

6. outline

9. *(should)*

8. diameter, radius.
   diameter, depth, local, circular

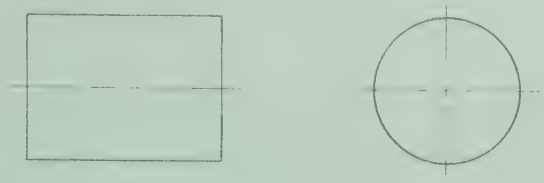
10. contour, characteristic

11. See text

12. See text

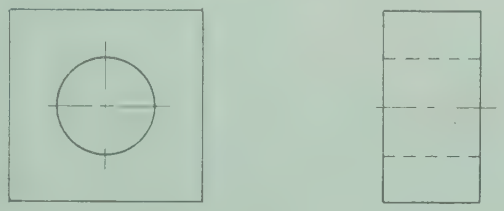
A. Four basic geometric shapes that comprise the contours of many objects are shown below. Indicate preferred size dimensions for each.

POSITIVE CYLINDER

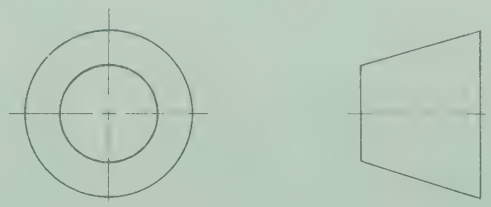


PRISM

NEGATIVE CYLINDER



TRUNCATED CONE



B. Visualize an object made up of several contours including those in a, b, and c above.

1. Sketch the necessary orthographic views for this object. Be sure to leave room for dimensions.
2. Indicate size dimensions for each contour making sure they conform with the preferred dimensions selected above.
3. Add dimensions to locate contours with respect to each other.
4. Add overall dimensions.
5. If any contour can be located in more ways than one, remove dimensions until this redundancy no longer exists. Be sure that each contour has a size and a location.

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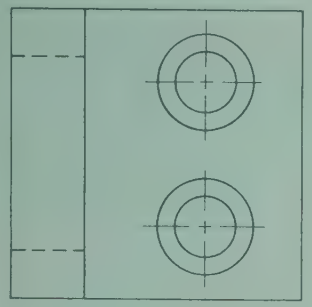
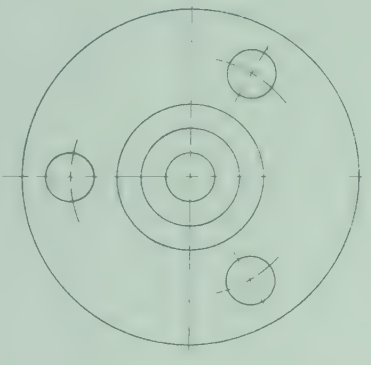
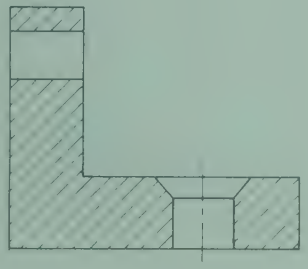
Place extension and dimension lines in preferred positions. Add numerals by scaling the drawings, full size, in inches, and give complete information for manufacture.

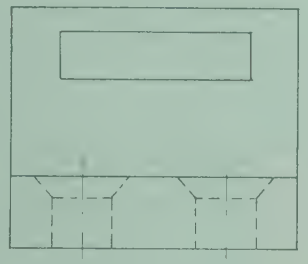
A.

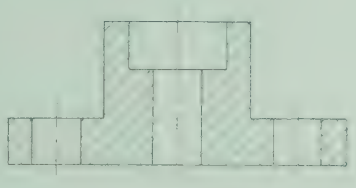


B.









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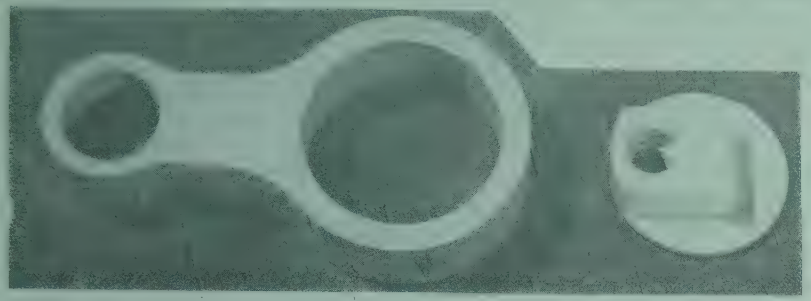
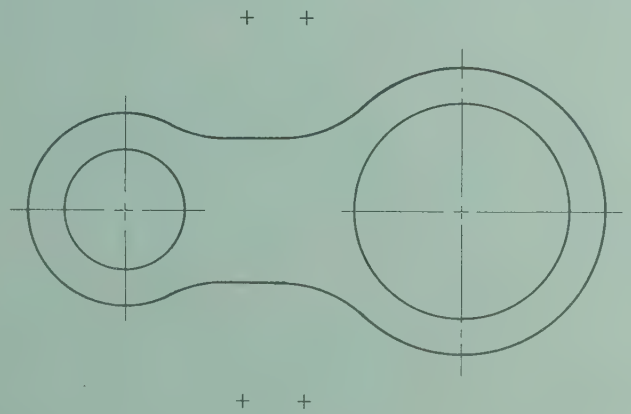


Courtesy of Sinteral Corporation

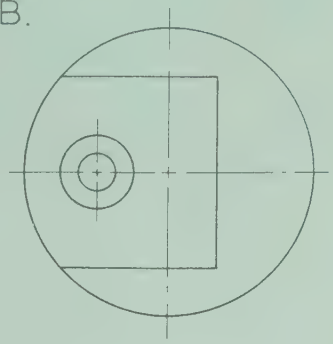
These are aluminum parts fabricated by powdered metallurgy by the Sinteral Corp. The parts can be identified as follows: left, a strap used in an electric motor; and right, a pad for a computer mechanism.

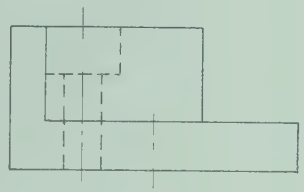
On this sheet orthographic projections of the parts in the picture on the left have been drawn. Completely dimension the drawings. Scale: half size. (Measure in inches.)

A.



B.





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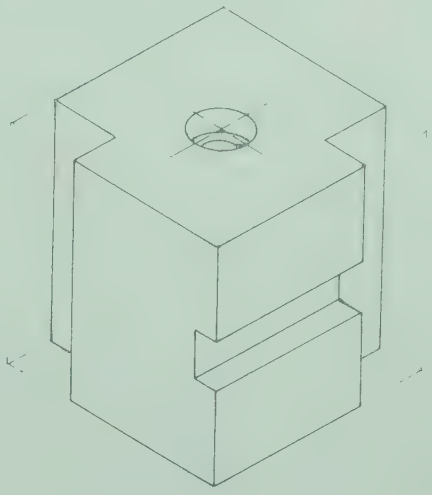
A. Prepare the necessary orthographic views of the Slide Stop by scaling in inches the pictorial which is shown half size.

B. Dimension the orthographic views with complete information for manufacture. The hole is 0.375 Dia. with a 0.625 Dia. counterbore, 0.25 deep.



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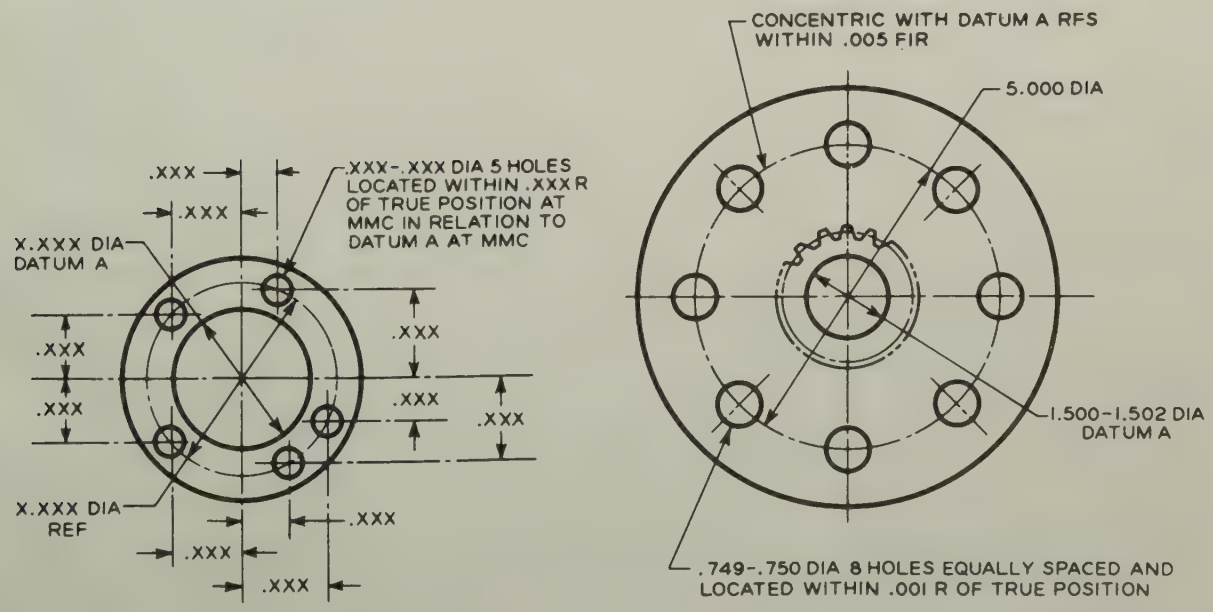
DIMENSIONING FOR PRODUCTION

USE

- The application of dimensions with accompanying notes and specifications is so prevalent throughout industry that it becomes obvious an engineer should have as good a background as possible in this important area.
- Dimensions are used primarily on detail drawings for the guidance of the fabricators who are responsible for the manufacture of the component parts of various mechanisms or products.
- Critical over all dimensions, center line dimensions or functional clearance distances are often placed on assembly drawings, catalog illustrations, etc.

OBJECTIVES

- To firmly instill an appreciation of the importance of production dimensioning techniques—why and where production dimensions are used—why and how dimensions should be given in a particular manner as a means of allowing the production and inspection people to clearly understand and efficiently produce the product with a minimum of error and ambiguity.
- To become familiar with the fundamentals and terms associated with mating parts, i.e., allowance, tolerance, interference and clearance fits and how to calculate limit dimensions and/or use tables prescribing certain classes of fits between mating parts.
- Above all, to acquire an over all concept of the essential and critical nature of production dimensioning as related to proper functioning of mating parts or surfaces and to its very important effect on cost of producing and assembling parts.



Courtesy ASA Z14.5—1957.

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DIMENSIONING AND PRODUCTION

Study carefully only those paragraphs in your text dealing with definitions, then close your book and check your memory and comprehension by answering the questions below. Give word answers or underline correct answers as appropriate.

1. The measurement used for general identification: _____ _____.

2. Theoretical size from which the _____ for a dimension are derived by application of allowances and tolerances: called _____ _____.

3. The measured size of an individual part after it is fabricated: _____ _____.

4. Limits are the specified _____ and _____ size of a dimension.

5. That condition which leaves the most material on the part after processing: _____.

6. *Design size* is that size to which the _____ is applied to give its _____.
   In the *unilateral system* the design size is the (MML) (mml). In the bilateral system, the design size is the (MML) (mml) (Average material condition).

7. Tolerance is the _____ _____ _____ in the actual size of a part or the location of some feature.

8. a. Allowance is the numerical value of the (loosest) (tightest) acceptable fit designated for _____ surfaces.
   b. Allowance can be *positive* (maximum) (minimum) acceptable (clearance) (interference); *negative* (maximum) (minumum) acceptable (clearance) (interference); or _____, (no clearance or interference).

9. A _____ system of tolerancing allows variation in two directions from a _____ size.

10. Add appropriate terms in the blanks below:

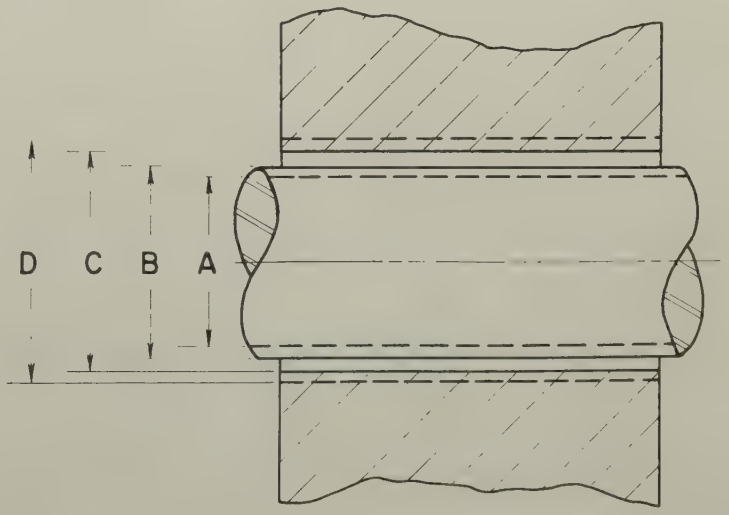
    A = Minimum shaft diameter.
    B = Maximum shaft diameter.
    C = Minimum hole diameter.
    D = Maximum hole diameter.

    D–C = _____

    D–A = _____

    C–B = _____

    B–A = _____



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COMPLETE THE FOLLOWING TABLES

English units are all in inches

Metric units are all in millimeters

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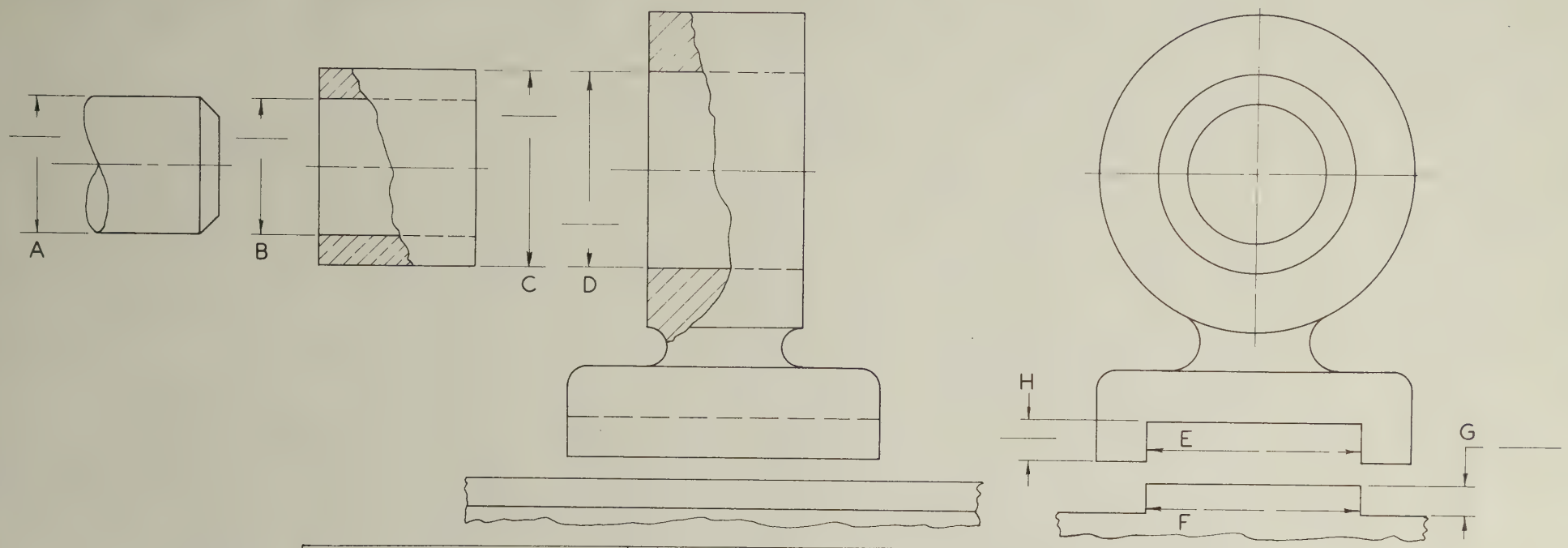
A. UNILATERAL DIMENSIONING

	NOM SIZE	TOL.	ALLOW.	BASIC HOLE		BASIC SHAFT		FIT (C, T, or I)
				HOLE	SHAFT	HOLE	SHAFT	
ENGLISH	0.8	0.002	+0.005					
	2					1.9986 / 1.9992	2.0000 / 1.9994	
METRIC	15	0.012	–0.010					
	60	0.05				60.10		

B. BILATERAL DIMENSIONING

	NOM SIZE	TOL.	ALLOW.	BASIC HOLE		BASIC SHAFT		FIT (C, T, or I)
				HOLE	SHAFT	HOLE	SHAFT	
ENGLISH	2		+.001	2.000 ±.005				
						1.203 ±.003	1.200 ±.003	
METRIC	20				19.984 ±.006			
	50	0.04	–0.04					

Fill in the limit dimensions on the drawing and complete the table.



	A & B	C & D	E & F	G & H
NOMINAL SIZE	0.8	1.2	1.3	0.2
BASIC SIZE				
TYPE OF FIT	RC5	FN1	RC4	RC8
TOLERANCE ON HOLE				
TOLERANCE ON SHAFT				
ALLOWANCE				

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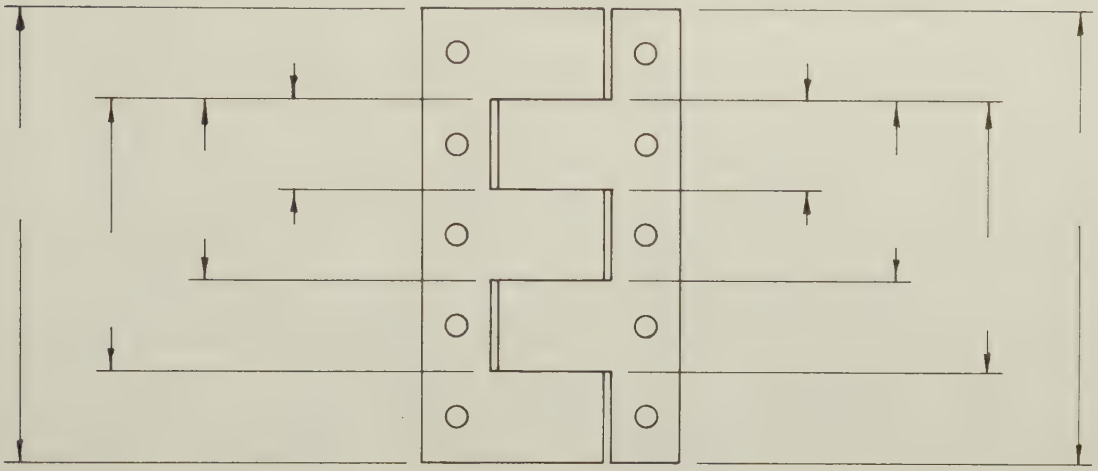
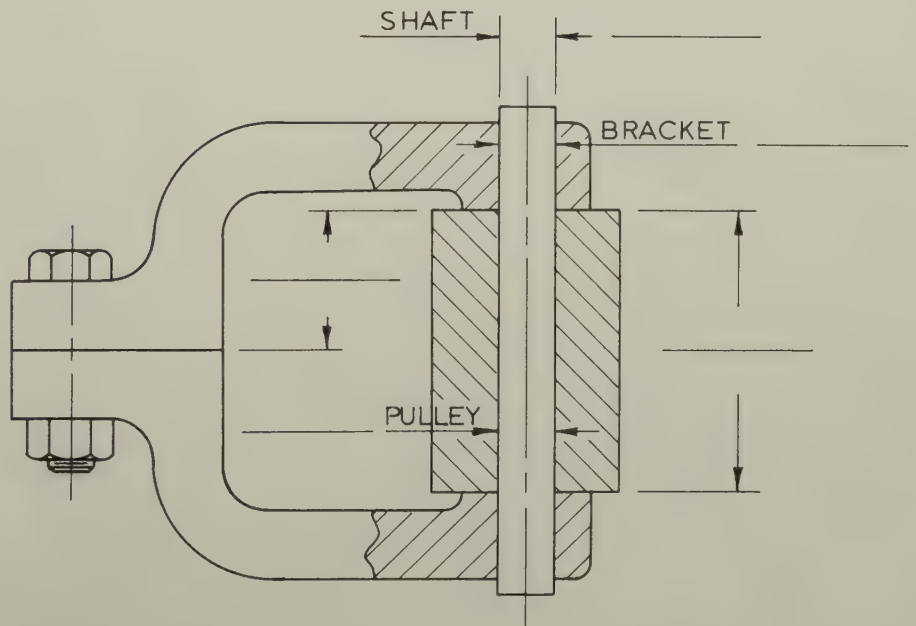
All dimensions are in millimeters

A. Complete the dimensions shown for the mating parts of a precision hinge. Where necessary to maintain an accurate fit use a +0.10 allowance and a 0.15 tolerance. On all other dimensions use a whole number to indicate size. Scale: 1:1



B. *Show all calculations.*

Complete the five dimensions indicated. The shaft diameter has a +0.066 allowance with the bracket holes and a –0.030 allowance with the pulley. Total minimum end play of the pulley is +0.180. Each tolerance is .015. Write an equation indicating the limits that determine minimum end play. Scale: 1:2



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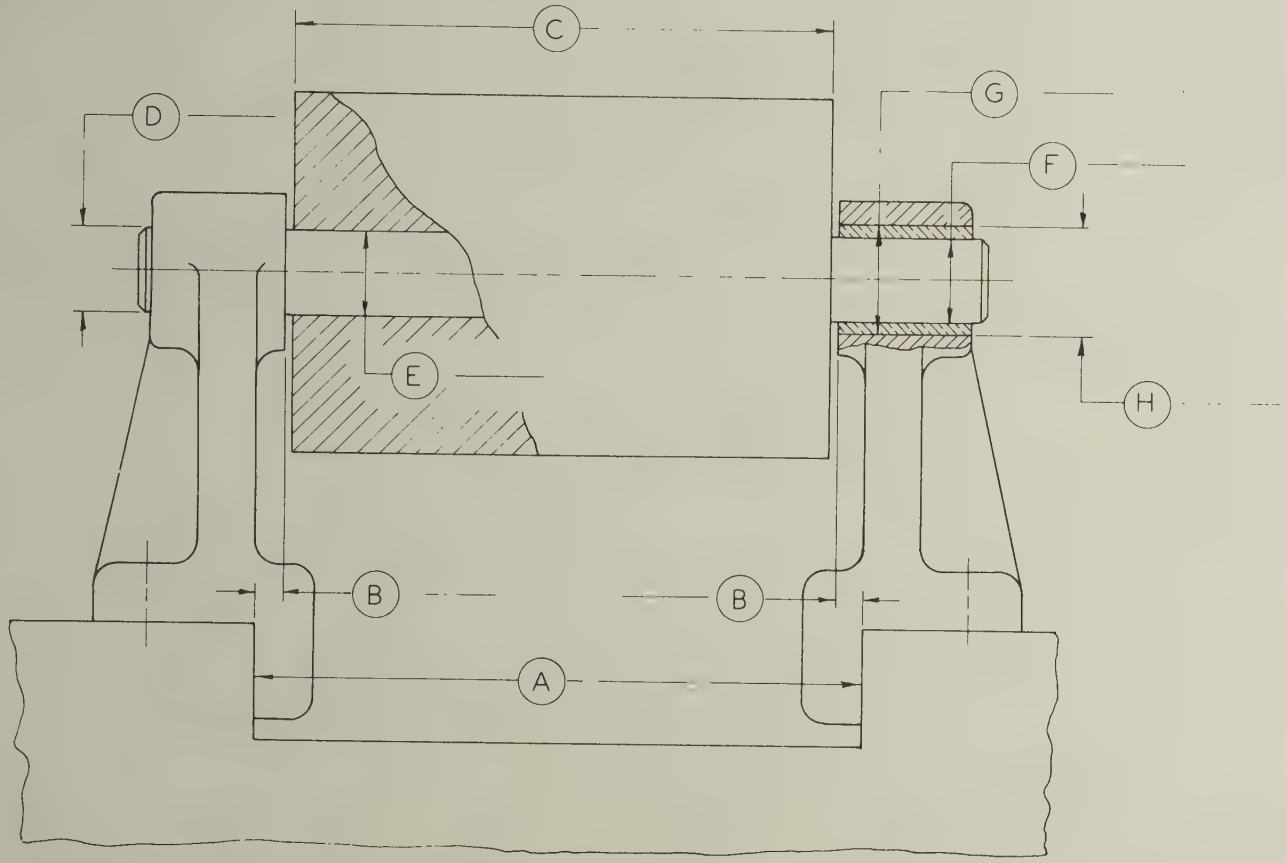
A. Determine the indicated limit dimensions from the following data:

1. Shaft D has an allowance of +0.025 with bushing hole F and −0.025 with pulley hole E. Tolerance is 0.012. Nominal diameter is 20 mm. Use basic shaft system.
2. Bushing H has an allowance of −0.025 with bracket hole G. Tolerance is 0.012. Nominal diameter is 30 mm. Basic Shaft.
3. Pulley length C is to have a minimum end play of +0.16 with the interior faces of the brackets. Nominal A is 160 mm. Nominal B is 6 mm. Tolerance on all dimensions is 0.05. Use basic hole system.

Show computations in an orderly manner. All dimensions are in millimeters.



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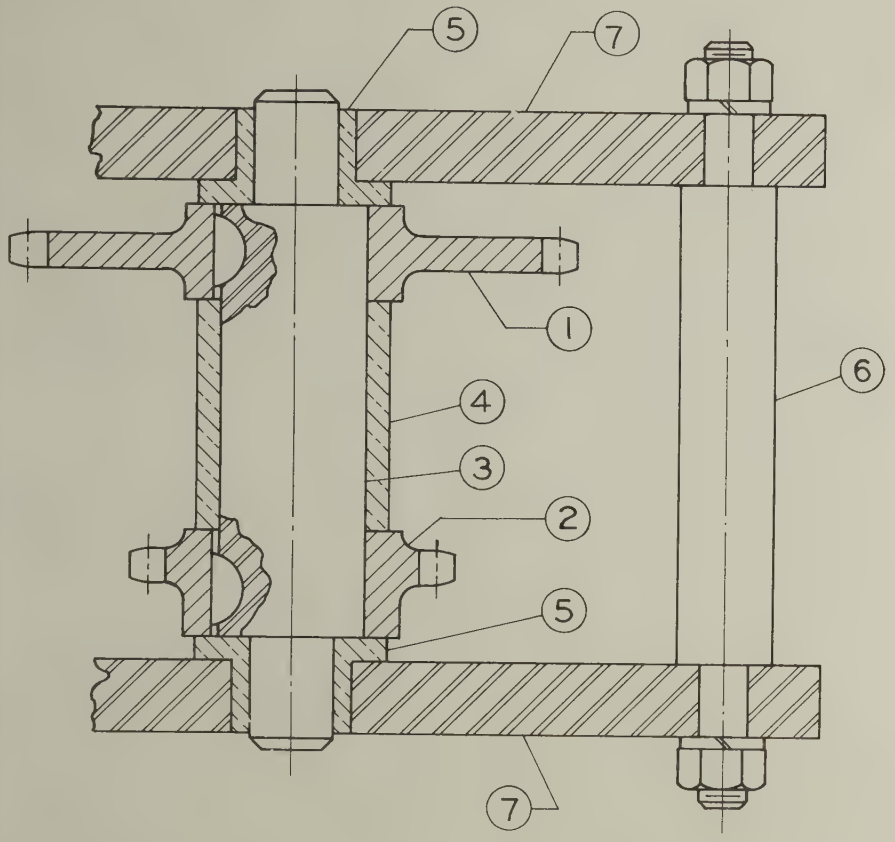
PRODUCTION DIMENSIONING

The section drawn below shows the mounting of an Idler Shaft in a Sprocket Assembly. Detail drawings of the parts involved are drawn and partially dimensioned on plate 99. Specifications concerning the fits between mating parts are in the table. Complete the dimensioning according to these specifications.

All work is to be done on plate 99. Calculations should be done on the back of the sheet.



SPEC	PART	NOM. SIZE	TOL.	NOTES
A	5,7	1.2		FN2
B	3,5	.9		RC4
C	6,7	.5		LC4
D	3	4.6	.002	Min end play of
D	5	.2	.002	shaft +0.005*
D	6	5	.002	5.000 Max
E	1,3	1.5		LC2
F	2,3	1.5		LC2
G	3,4	1.5		LC2
H	1	1	.002	Total
H	2	1.1	.002	Allow
H	4	2.5	.002	+0.002**
J	1,3			No. 406
	2,3			Woodruff Key
K	3			.1 X .1 Chamfer
L	6			.05 X .05 Chamfer
M	6			1/2-13 UNC

*Write an equation indicating the limits involved at minimum end play of the shaft and show calculations for the dimension on part 3.

**The sum of the lengths of parts 1, 2 and 4 must be less than dimension D on part 3. Write an equation indicating the limits involved at the closest condition and calculate the length of the spacer.

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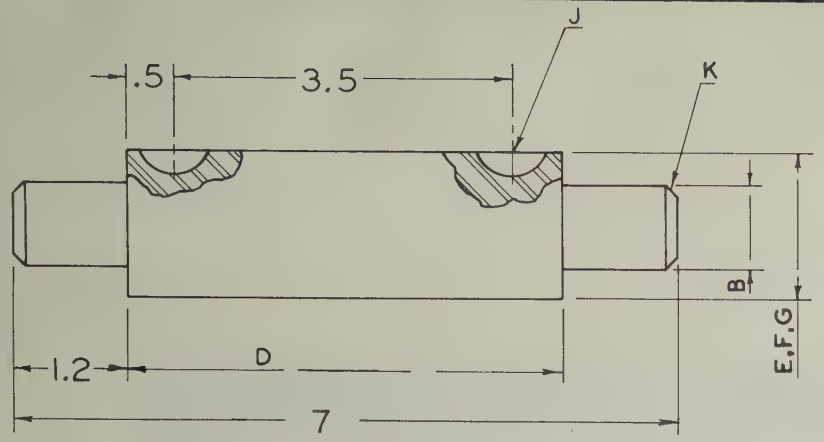
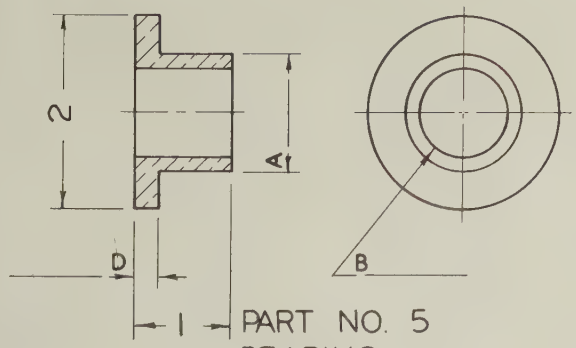
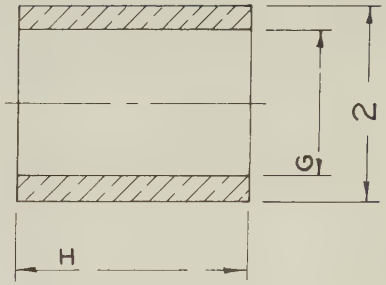


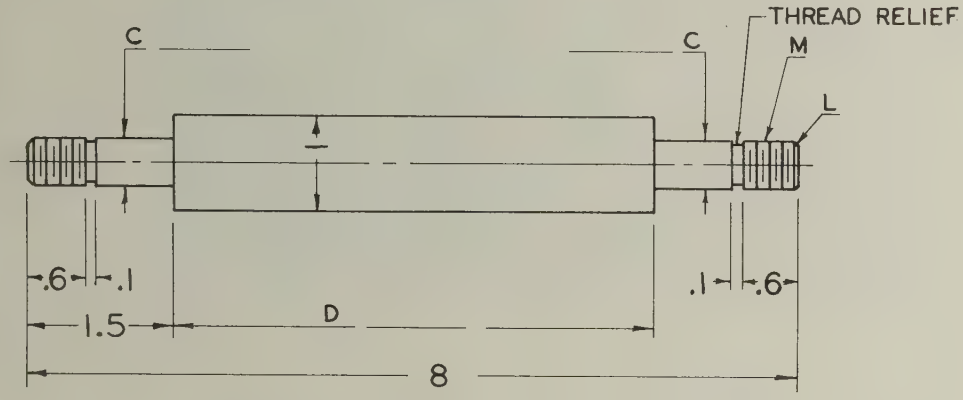
PART NO. 3
SHAFT
1 REQ'D
MAT'L - C.R.S.



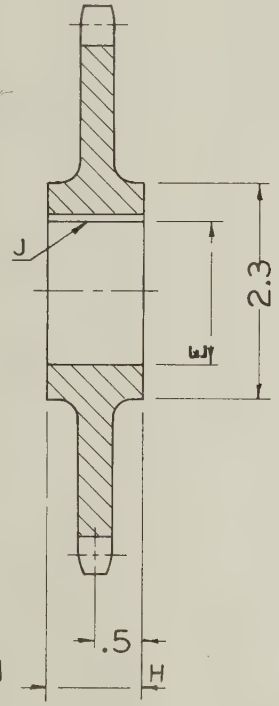
PART NO. 5
BEARING
2 REQ'D
MAT'L - PHOS. BRONZE



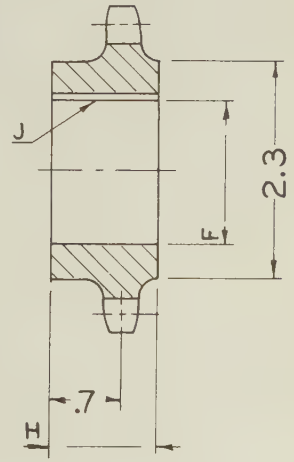
PART NO. 4
SPACER
1 REQ'D
MAT'L - BRONZE



PART NO. 6
POST SPACER
4 REQ'D
MAT'L - C.R.S.



PART NO. 1
SPROCKET
NO. 50 ROLLER CHAIN
4.99 P.D. 25 TEETH
1 REQ'D
MAT'L - CAST STEEL



PART NO. 2
SPROCKET
NO. 50 ROLLER CHAIN
3.01 P.D. 15 TEETH
1 REQ'D
MAT'L - CAST STEEL

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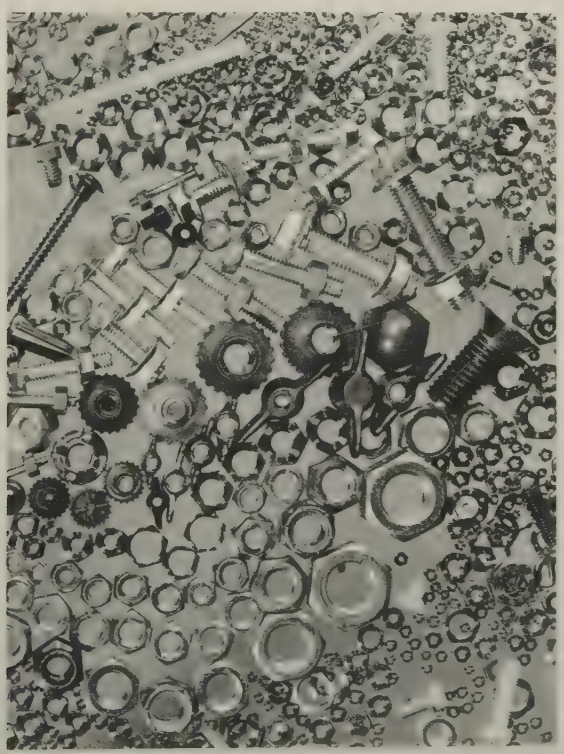
STANDARD FASTENERS

USE

- Standard fasteners are used to hold component parts in their assembled and/or functional positions in an almost infinite number and variety of industrial applications.
- More than 250,000 nuts, bolts, rivets and other fastener in more than 2000 different sizes are required to hold the *first stage only,* of the Saturn 5 Rocket together.
- About 600 plants have as their principal business the manufacture of more than *100 billion* nuts, bolts, screws, rivets, etc. at an annual value of over *$1.5 billion.* More than 60,000 people are employed by the fastener industry.
- There are about 500,000 standard and 3,000,000 special sizes, kinds and shapes of fasteners in a wide and growing number of *materials such as metals, plastics, ceramics, fiber glass, etc.*

OBJECTIVES

- To become familiar with many of the common threaded fasteners, how they are represented on engineering drawings, how they are specified for purposes of ordering or storing and some of the more important unique features of various threaded fasteners.

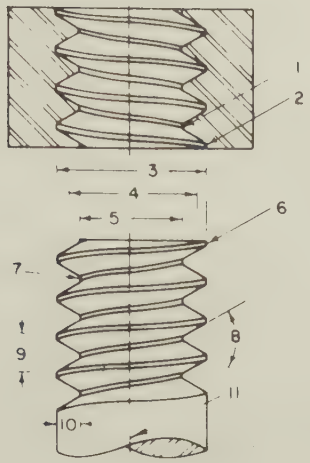


Courtesy of Industrial Fasteners Institute

THREADED FASTENERS

A. By labeled sketches illustrate schematic and simplified thread representation, for an external thread.

B. Match this list of screw thread nomenclature with the numbers on the accompanying drawing.



Crest _____

Thread Angle _____

Root _____

Axis _____

Depth of Thread _____

Pitch _____

Major Dia. _____

Minor Dia. _____

Pitch Dia. _____

C. Identify each part of the given thread specification: 3/4—10UNC—3B.

D. Write a complete specification for a 3/4 inch long, number 4, round head, machine screw having UNC threads.

E. Indicate standard dimensions of the fastener specified in the preceding question by means of a small freehand sketch.

F. By labeled sketches illustrate the types of heads available on American Standard Cap Screws.

G. What type of tool would be necessary to tighten a cap screw having (1) hexagon (2) flat, or (3) socket head shapes?

1.

2.

3.

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THREADED FASTENERS

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A. The two partial assemblies show applications for threaded fasteners. The parts are to be fastened together in "a" by a bolt with nut and lock washer, and in "b" by a recessed socket head cap screw threaded into a blind hole. Assume 5/16 nominal size fasteners and allow clearance with the exception of mating surfaces.

1. What is the diameter of the drilled hole in parts 1, 2 and 3?

2. What is the minimum standard length for the bolt for assembly "a"?

3. Assuming minimum thread engagement equal to the thickness of an unfinished nut, what is the standard length for the cap screw in assembly "b"?

4. What diameter tap drill is used in part 4?

5. What is the depth of thread in part 4 assuming thread depth 3/16 inch deeper than the fastener?

6. What is the tap drill depth assuming at least 4 pitches beyond the thread depth?

7. Complete the section views for "a" and "b" using well proportioned sketches.

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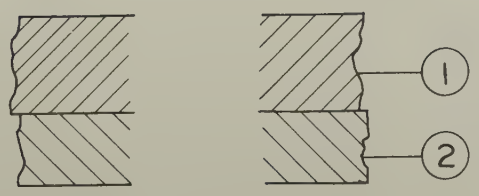
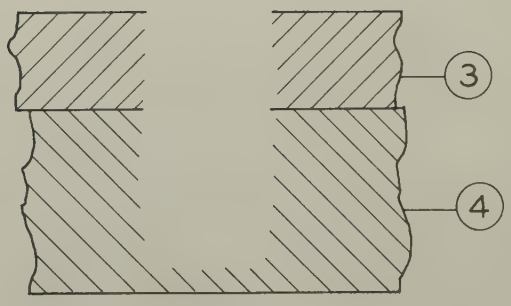
a.



b.



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FASTENERS–GENERAL

A. Classification

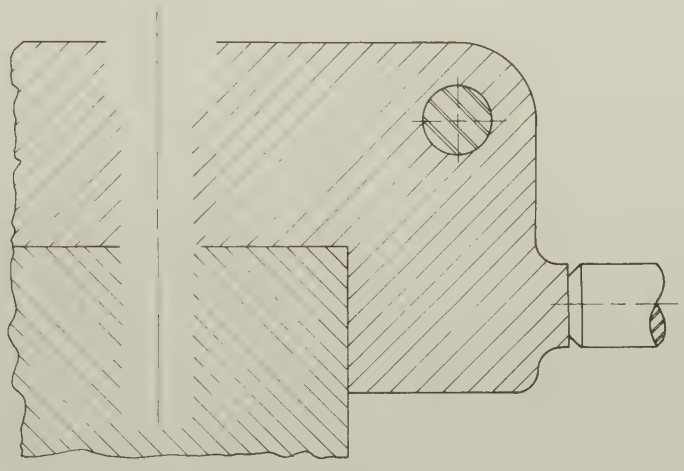
1. The types of fasteners of interest to the engineer can generally be classified as _____, _____ and _____.

2. Bolts and nuts, cap screws, setscrews, etc., are examples of _____ fasteners.

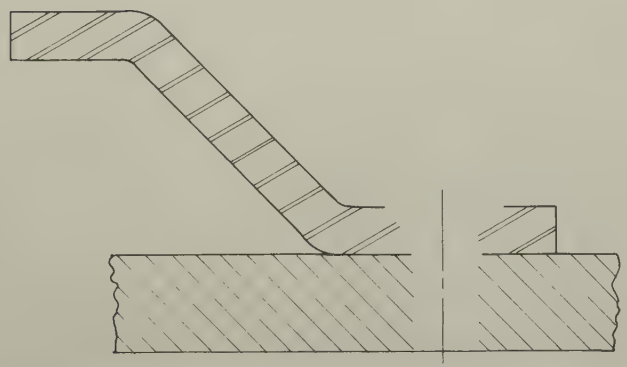
3. Keys, splines, pins and springs are examples of _____ fasteners.

4. Riveting, soldering, brazing, gluing and welding are examples of _____ fasteners.

B. Draw the fasteners indicated and identify each with a proper specification.



1. Hexagonal socket head cap screw, 5/16 X 1.25 long.



2. Flat head machine screw, 1/4 X .625 long.

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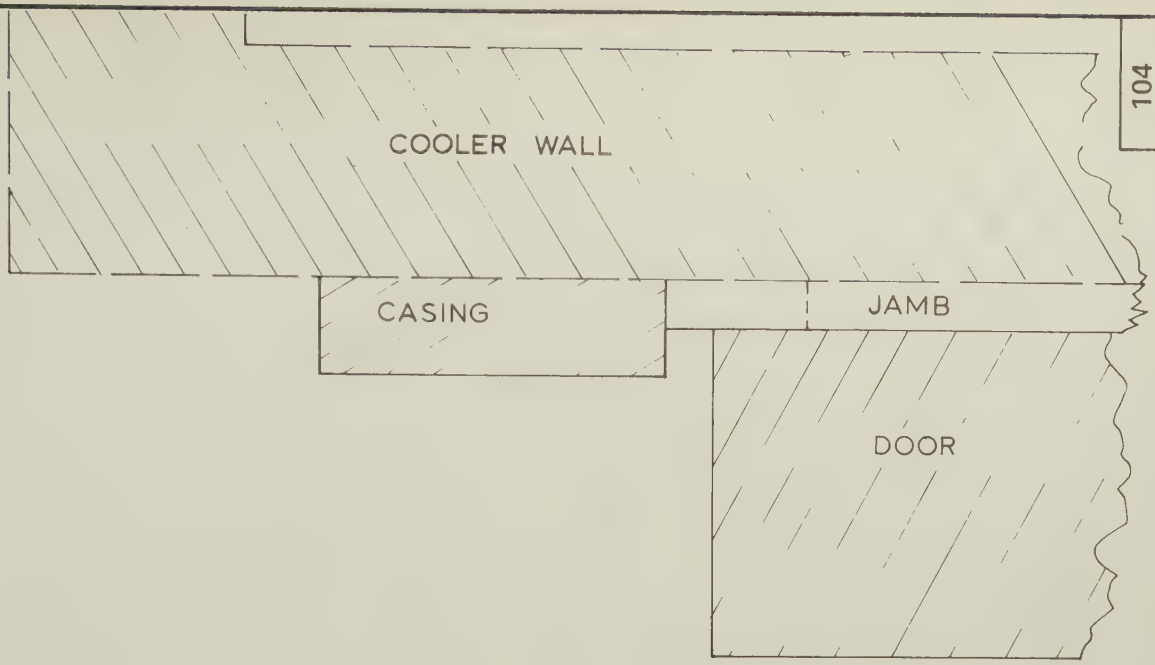

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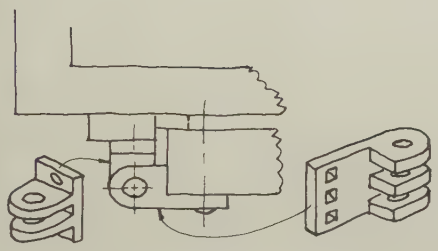

HINGE LAYOUT

Given: Partial plan view of refrigeration wall and door and pictorial sketches (not to scale) of heavy duty stainless steel hinges. Hinges are to be machined to the shapes indicated. Pin should have 0.005 clearance and mating surfaces between slots and hangers 0.005. Three hinges required for each door. Door must open 195°.

Casings hinge nominal sizes: 10 high; 5 wide; 7 deep; hinge back 1" thick; 2" slots and hangers (mating surfaces); .75 drill × 82° c' sink (3) holes; 1.5" dia. pin hole.

Door hinge nominal size: 10 high; 11 long; 5 deep; back, 1" thick; 2" slots and hangers; 1.5 dia. pin hole; (3) .75 sq. holes (to accommodate sq. shank on stainless steel carriage bolts. Scale: 1" = 4"

A. Complete orthographic layout including the front projection of the *hinges* in closed position and a phantom of the hinges in open (195°) position.

B. Make detail drawings of hinges and pin.

C. Make assembly drawing of hinges and pin.

D. Make Bill of Materials.

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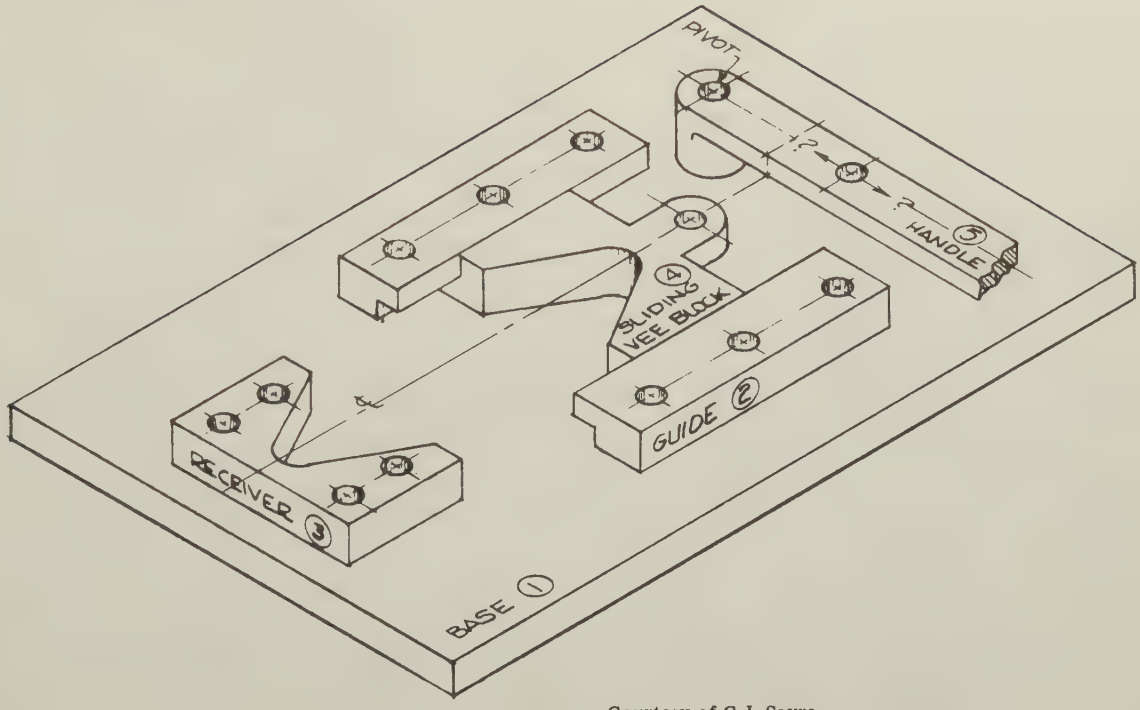
PROJECT: MECHANISMS



Courtesy of C.J. Sayre

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A clamping device is shown in pictorial to a scale of 1" = 4". There are two options for the student to choose from in this project. Both involve making two complete and well-executed drawings. The pictorial should be scaled to the nearest .1". Nominal (non-critical) dimensions shall be specified to two decimal places. Dimensions affecting fit shall be specified to four decimal places, as given in ANSI B4.1 tables.

Option I: By carefully scaling dimensions from the illustration, make good complete drawing of part (2) and (4) . The sliding block must have a class RC3 fit in its guides in order for it to slide smoothly. For purposes of dimensioning it will be assumed that the guides, part (2) , are fixed to the baseplate by means of pins (Dia. = .5000 ±.0002) which have an FN 2 fit with both the base plate (1) and parts (2) . It is also assumed that the base plate holes are precisely 6.0000 center to center distance.

Option II: Design an operating link to connect the handle (5) to the sliding block (4) . It is necessary to assure that the slider shall move forward exactly 3 inches as the handle rotates 30° clockwise from its illustrated position. The end holes of the link shall have an RC 4 fit on standard pins measuring .5000 ±.0002 diameter. Both the layout and link detail drawings are required. Lengths of both the link member and the handle radius shall be identified clearly and dimensioned properly on the layout drawing.

PROJECT: ELECTRICAL

An experimental design for a new 15" Woofer hi-fi speaker is proposed with the following specifications.

Woofer cone material: 0.125 spun fiber glass
15" outside diameter
4" cone depth

Solenoid: Material is Fiberglass with length and inside diameter shown below. Wall thickness = $\frac{0.050}{0.048}$

400 turns of #20 magnet Formar covred wire are to be wound in four (4) layers as shown below. Wire dia. = 0.032" (max.)

Magnet: Material is Alnico V, overall nominal dimensions are 2.5D× 6.0

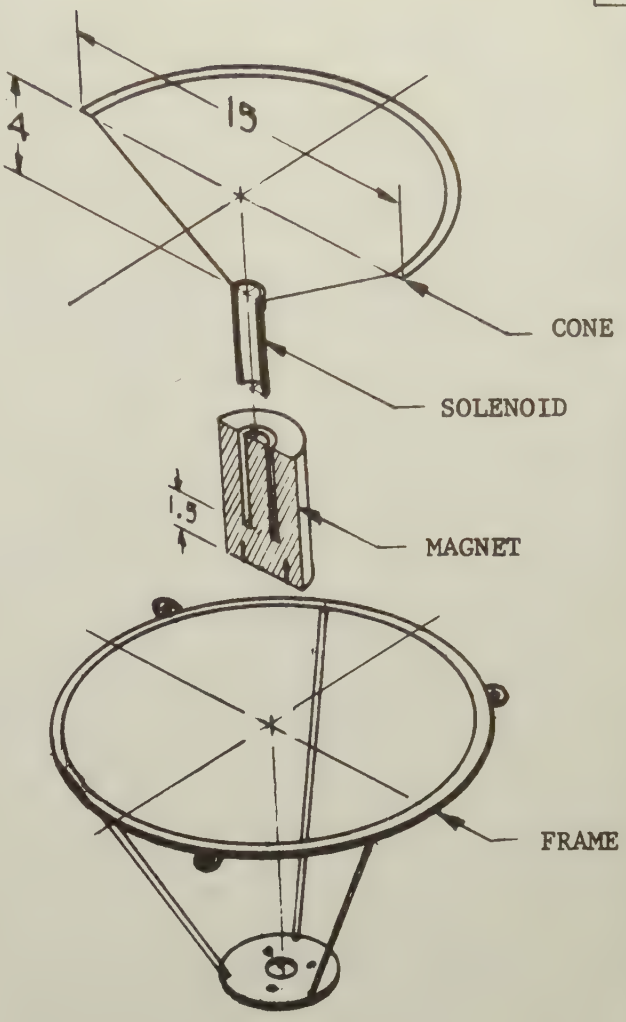
With these basic specifications given determine and draw as assigned:

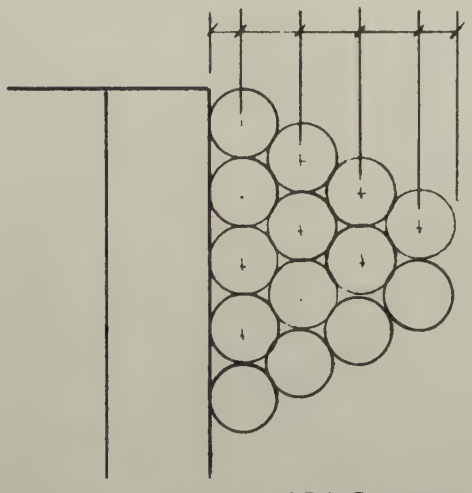
a. Detail Solenoid computing "W" and "D".

b. Detail Magnet such that solenoid will fit into cylinder with .010 clearance to all surfaces.

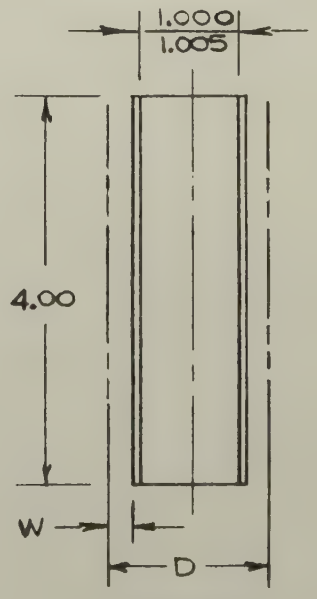
c. Assembly drawing of cone, solenoid and magnet to allow 1" axial motion of cone/solenoid in magnet.

d. Design frame to hold parts.





Courtesy of G.A. Granneman
and W.C. Dowling



SOLENOID
CROSS SECTION
HALF SIZE

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PROJECT: PROCESSES

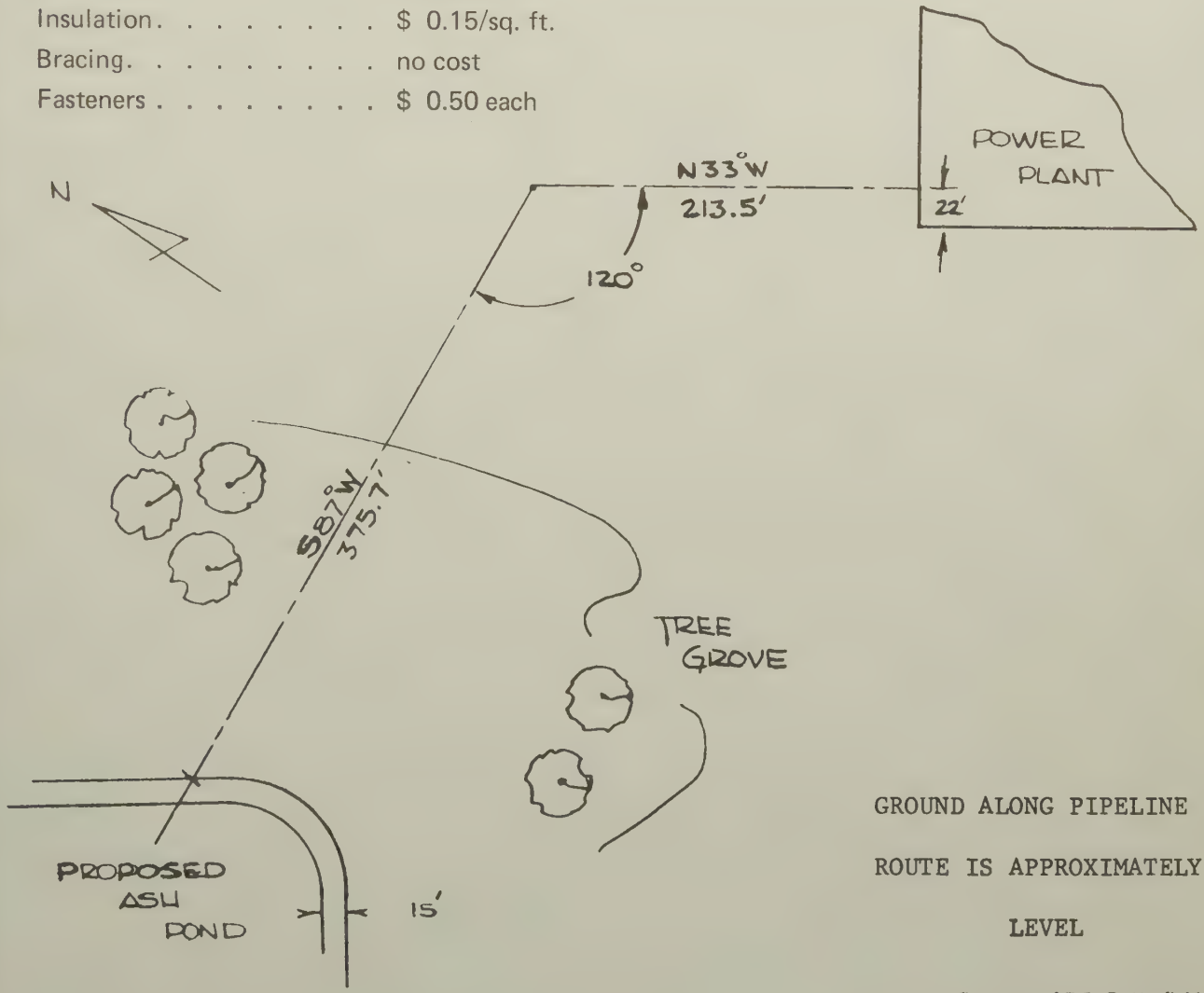
One method for disposing of ashes from a power plant involves mixing the ashes with water to form a slurry. The slurry is then transported by pipeline to a shallow man-made pond, where the water is evaporated.

The power plant shown in the sketch below must install this type of system. The pipeline is 8" in diameter, is covered by 2" of insulation, and is 10' above ground. The plant has in storage 500 pieces of lumber which are 4" × 4" × 16', which it recovered from a salvage operation last year. Utilizing this lumber, design a brace for the pipeline, which will be placed along the pipeline at 10' c-c.

In addition to the detail drawing of the brace design, make a layout drawing of the sketch below, using a suitable scale, and a bill of materials for the project. Include an estimate of cost using information provided by your instructor.

COST ESTIMATES

Pipe	$12.00/ln. ft.
Insulation	$ 0.15/sq. ft.
Bracing	no cost
Fasteners	$ 0.50 each



GROUND ALONG PIPELINE ROUTE IS APPROXIMATELY LEVEL

Courtesy of B.L. Butterfield

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